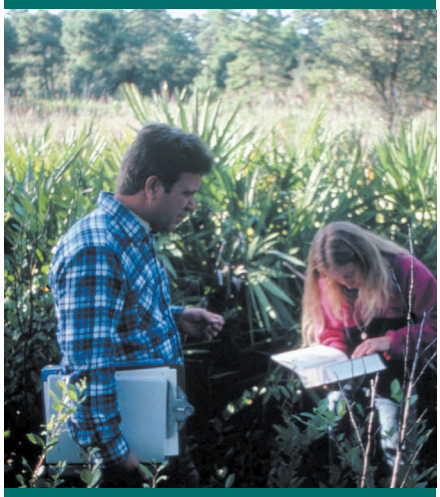

IOWA'S BIOSCIENCE PATHWAY FOR DEVELOPMENT

PREPARED FOR:
The Iowa Department of Economic Development

PREPARED BY:
Technology Partnership Practice
Battelle

July 2004

Battelle
The Business *of* Innovation

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Alumni Associations
Business Associations
Commodity Groups
Community Colleges
Community Economic Development Professionals
Farm Organizations
Foundations
Government Departments and Programs
Private Businesses
Private Colleges
Regent Institutions
Utility Companies
Venture Capitalists

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Iowa's Bioscience Pathway for Development

Summary and Technical Reports

Prepared for:
The Iowa Department of Economic Development

Prepared by:
Technology Partnership Practice

Battelle

July 2004

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Acronyms

AUTM	Association of University Technology Managers
BLS	Bureau of Labor Statistics, U.S. Department of Labor
CCUR	Center for Crops Utilization Research
CIAG	Center for Integrated Animal Genomics
CIRAS	Center for Industrial Research and Service
FIRE	Finance, insurance, and real estate
FTE	Full-time employee
GMP	Good Manufacturing Practices
GSP	Gross state product
IBA	Iowa Biotechnology Association
ICIB	Iowa Capital Investment Board
ICIC	Iowa Capital Investment Corporation
IDED	Iowa Department of Economic Development
IDM	Institute for Decision Making
IHCC	Indian Hills Community College
IP	Intellectual Property
IPRT	Institute for Physical Research and Technology
ISI	Institute for Scientific Information
ISU	Iowa State University
LQ	Location quotient
NIH	National Institutes of Health
NSF	National Science Foundation
R&D	Research and development
SBDC	Small business development center
SBIR	Small Business Innovation Research
STTR	Small Business Technology Transfer
SWOT	Strengths, weaknesses, opportunities, and threats
TPP	Battelle Technology Partnership Practice
U of I	University of Iowa
UNI	University of Northern Iowa
USDA	U.S. Department of Agriculture
WARF	Wisconsin Alumni Research Foundation

Summary Report

As the 21st century progresses, the U.S. economy is facing a time of great change that severely impacts the ability of states to maintain their normal economic *modus operandi.* In this nation, where states are free to chart their own courses through the free market economy, the pace of change is likely to produce winners and losers. In winning states, the private sector—with catalytic support from the public sector—is making the proactive decisions and investments that will spur future growth; in other states, they are hampered by a lack of vision and are failing to act at all.

Increasingly, it is technology-based economic development, driven by innovation, talent, and investment capital, that is shaping the future of successful U.S. state economies. An area of science and technology in which rapid advancements are driving development opportunities is that of bioscience. Human, animal, and plant biosciences are driving business opportunities in a broad range of areas such as drugs and pharmaceuticals, research and testing, medical devices, biorenewable chemicals, biomaterials, and biofuels. States, such as Iowa, with core strengths in each of these areas have the opportunity to position themselves to build their bioscience-based economies.

Aware of this potential economic opportunity, the Iowa Department of Economic Development (IDED) retained the services of Battelle's Technology Partnership Practice (TPP) to assess Iowa's core bioscience competencies and to produce a formal strategy and roadmap to drive bioscience growth in the state. The biosciences are complex and diverse; key challenges for any state are to determine which areas of bioscience to pursue and how to allocate resources to accomplish their efficient development. Battelle's analysis provides this guidance.

This strategic roadmap or pathway outlines a comprehensive approach to bioscience-based economic development that requires a long-term commitment from the state, its institutions, and the commercial bioscience sector. Leading technology states have accomplished their growth usually over a decade or more, using a sustained commitment to strategies and actions that build critical mass in research and commercial biosciences—Iowa will need to do no less.

Iowa comes to this path with considerable strengths. It is home to two major bioscience research universities (Iowa State University and the University of Iowa), with supplemental expertise provided by the University of Northern Iowa. In addition to its academic strengths, Iowa is home to a diverse range of bioscience industry, incorporating agbiosciences, traditional biotechnology, pharmaceuticals, medical devices, and various additional sectors. Also, a recent study for BIO, the national biotechnology trade association, compared Iowa's bioscience industry base with the rest of the nation. The report pointed to Iowa's national leadership role in bioenergy, biofuels, and related biomass initiatives. Iowa is one of only six states in the nation that have both a large employment base and a significant specialization in agricultural feedstock and chemicals, which includes organic and agricultural chemicals and agricultural processing and is focused on industrial applications geared toward production agriculture, energy, industrial commodities, and specialty health products.[1]

A significant portion of these advances in Iowa's bioscience-based economy can be directly attributed to the initiatives of the state's leaders. In 2001, Governor Vilsack launched a statewide technology cluster

[1] Battelle Technology Partnership Practice and SSTI. *Laboratories of Innovation: State Bioscience Initiatives 2004*, www.bio.org, June 2004.

initiative that identified three areas of focus: biosciences, advanced manufacturing, and information solutions. Furthering this effort, in 2003 the Iowa Legislature approved the Iowa Values Fund, a 7-year, $503 million state investment in the three cluster areas. The goals of this fund are to help move and grow Iowa's economy, create jobs, and help generate wealth for Iowans. The Iowa Values Fund is composed of four main components:

- Business development and assistance
- University research and development
- Workforce training
- Quality of life.

Iowa also has focused significant programmatic investments to develop tax incentives for research and development, to help universities turn research into business opportunities, and to create venture capital funding to aid business start-ups. For instance, during the 2002 session, Governor Vilsack and the Iowa Legislature enacted an economic stimulus measure designed to encourage private venture capital investment in emerging, expanding, and restructuring business enterprises in communities throughout Iowa. To facilitate the goals set forth in the Act, Governor Vilsack and the Legislature authorized the formation of the Iowa Capital Investment Corporation (ICIC) for the purpose of mobilizing tax credits to incentivize private venture capital investments. ICIC's primary purpose is to organize and manage the Iowa Fund of Funds (Fund of Funds). The Fund of Funds is a private, for-profit limited partnership authorized to make investments in private venture capital funds. To facilitate private investment in the Fund of Funds and minimize the need for public appropriations, the Legislature also authorized the issuance of contingent tax credits to guarantee, at least partially, investments in the Fund of Funds. The Iowa Capital Investment Board (ICIB) oversees the issuance of the tax credits contingent on certain ICIB-developed criteria.

Therefore, while Iowa may not yet have reached a critical mass of bioscience activity that places it among the leading states in all areas of the biosciences, as it now has in agricultural feedstock and chemicals, Iowa has the potential to build on its existing assets and increase its economic and research bases in other segments of the biosciences as well. To that end, this roadmap identifies specific strategies and actions that will serve, if acted upon, to help realize a bioscience-driven economy through leveraging existing organizations and programs and developing new initiatives. In other words, this strategy aims to provide guidance for building a strong Iowa economy for the future.

IOWA'S BIOSCIENCE VISION

With strong public and private leadership and long-term commitment on the part of Iowa's research institutions, business community, nonprofit community, and state and local governments, it is reasonable to expect that Iowa can achieve the following vision by 2014:

> *Iowa is a leading Midwestern state with a comprehensive set of strengths in the plant, animal, and human sciences. Iowa is a leader in the application of biorenewable resources to create value-added products and has become a significant player in the production of advanced food products, drugs, biologics, and related biomedical technologies. The Iowa biosciences are characterized by strong public-private and industry-university relationships, resulting in a strong base of bioscience companies operating in Iowa in the development and production of plant, animal and human bioscience products.*

MISSION

To achieve this vision, Iowa must make the following efforts to approach its future in the biosciences:

- **Invest in the further development of key R&D platforms at Iowa's regent universities**[2], including facilities, equipment, scientific resources, and the attraction and retention of Eminent Scholars and their research teams to generate commercializable innovations from these investments.
- **Put in place incentives, programs, and organizations that will facilitate and encourage the translation of bioscience innovation into products, processes, and other mechanisms of economic value and wealth creation for Iowa**.
- **Secure capital funding sources** that will provide the financial resources necessary to move innovative technology from the research bench to commercialization and into full-fledged entrepreneurial businesses growing, expanding, and succeeding from their base in Iowa.
- **Apply itself to the creation of an educational, economic, and social environment conducive to the creation, attraction, and retention of human talent** at all key bioscience business skill levels—from R&D scientists to experienced management and production personnel.

Iowa has the potential to develop and sustain leadership in key focused bioscience platforms, but realizing that potential will require Iowa to adopt the best practices proven as drivers of technology-based economic development in other states, including

- ***Engaged universities taking an active leadership role;***
- ***Intensive networking across sectors and with industry;***
- ***Available capital covering all stages of the business cycle;***
- ***Discretionary federal or other R&D funding support;***
- ***Workforce and talent pool on which to build and sustain efforts;***
- ***Access to specialized facilities and equipment;***
- ***Stable and supportive business, tax, regulatory, and incentive policies; and***
- ***Patience and a long-term perspective.***

METHODOLOGY

To facilitate an in-depth understanding of core bioscience opportunities and to develop a strategy for building the Iowa bioscience economy, the IDED engaged TPP to develop a state bioscience strategy and pathway in a two-phase effort:

- **Economic and core competency analyses of the biosciences in Iowa**. This Phase I work was released March 2004 in the report entitled, *The State of Iowa Biosciences Path for Development: Economic and Core Competency Analyses*. In this report, Battelle examined the current quantitative position of Iowa in commercial bioscience sectors and in academic bioscience R&D and produced a formal assessment of core competencies and fundamental strength platforms upon which Iowa's bioscience economy may be built.

[2] Iowa's regent universities include Iowa State University, The University of Iowa, and the University of Northern Iowa.

- **A strategy and actions roadmap** or pathway. This Phase II report, embodied herein, provides a summary of the Phase I findings and completes the Iowa Bioscience Pathway by providing specific guidance in bioscience-based economic development.

To complete both Phases I and II assignments, Battelle used both quantitative and qualitative techniques, including more than 500 face-to-face interviews with representatives of industry, academe, government, and other stakeholder organizations in Iowa.[3] Meeting the key goals for the project required that Battelle

- Conduct an economic analysis of Iowa's existing bioscience industry, identifying trends, current strengths, emerging industries, and emerging clusters within the biosciences;
- Assess Iowa's position in bioscience research and provide a detailed understanding of the bioscience core competencies that form platforms for future bioscience development;
- Identify key barriers and gaps in private and public investments, policies, programs, and activities that negatively impact Iowa's ability to realize its development potential from the biosciences;
- Outline a series of specific strategies and actions designed to fill in the gaps and maximize the economic advantage of Iowa's core bioscience strengths; and
- Provide an implementation plan, showing action priorities, estimated resource requirements, and an organizational structure for moving the roadmap forward.

IOWA'S BIOSCIENCE BASE

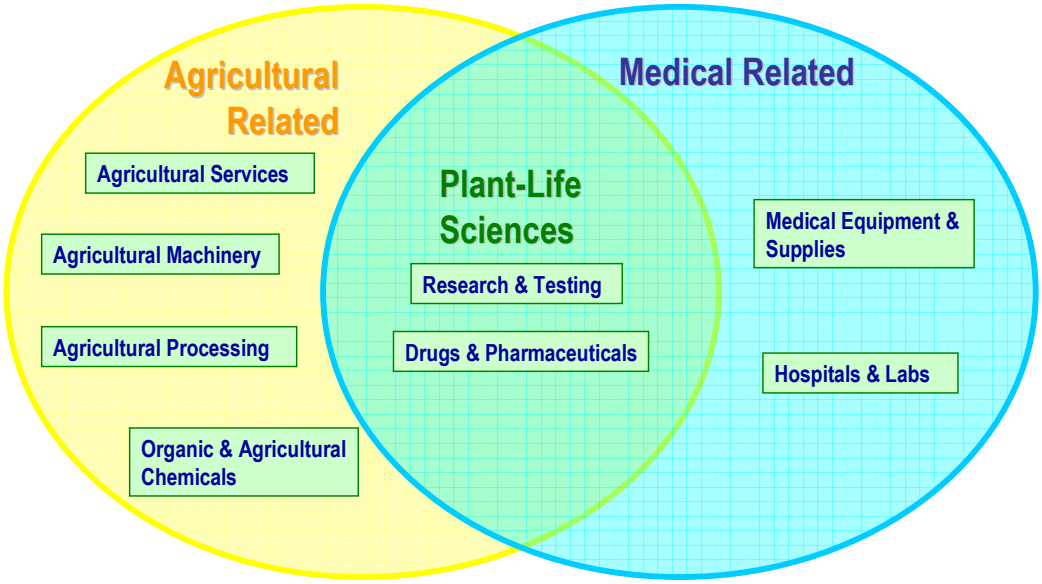
Iowa's Bioscience Industry Sector

This analysis addressed the diversity of the bioscience industry by dividing it into three sectors: agricultural, medical, and plant-life sciences. The agricultural sector consists of those industrial subsectors involved in developing, supporting, and manufacturing new farming and food production technologies for advancing health and nutrition. The medical sector consists of those industrial subsectors involved in manufacturing and developing clinical techniques aimed at and directed toward advancing human health care. The plant-life sciences sector consists of those industrial subsectors involved in research, testing, developing, and manufacturing clinical and agronomic techniques and products for improving the functions of living organisms.

Eight major bioscience subsectors were included in the economic analysis (Figure SR-1). These subsectors encompass a wide variety of industrial activity upon which Iowa is well situated to further build and strengthen its overall bioscience base.

[3] Many individuals were interviewed for both Phase I and Phase II of this analysis.

Figure SR-1: Broadly Defined Iowa "Bioscience" Industry



Iowa's Bioscience Cluster

Recent employment trends since 2000 indicate a bioscience growth rate that is above the national average. In Iowa, the bioscience industry experienced above-average employment growth between 2000 and 2002, growing by 5.3 percent and gaining 4,179 jobs. In 2002, the Iowa bioscience industry employed 82,849 individuals across 1,856 establishments. Even more promising is that this growth rate was above the national average. The bioscience industry across the United States grew at a rate of 3.7 percent between 2000 and 2002.

The bioscience industry also represents a sizable portion of Iowa's economy. Bioscience employment concentrations over the same time period consistently accounted for a larger share of state private-sector employment than at the national level. In 2002, bioscience employment in Iowa accounted for 7.0 percent of total state private-sector employment. Nationally, the bioscience industry accounted for 5.6 percent of total private-sector employment.

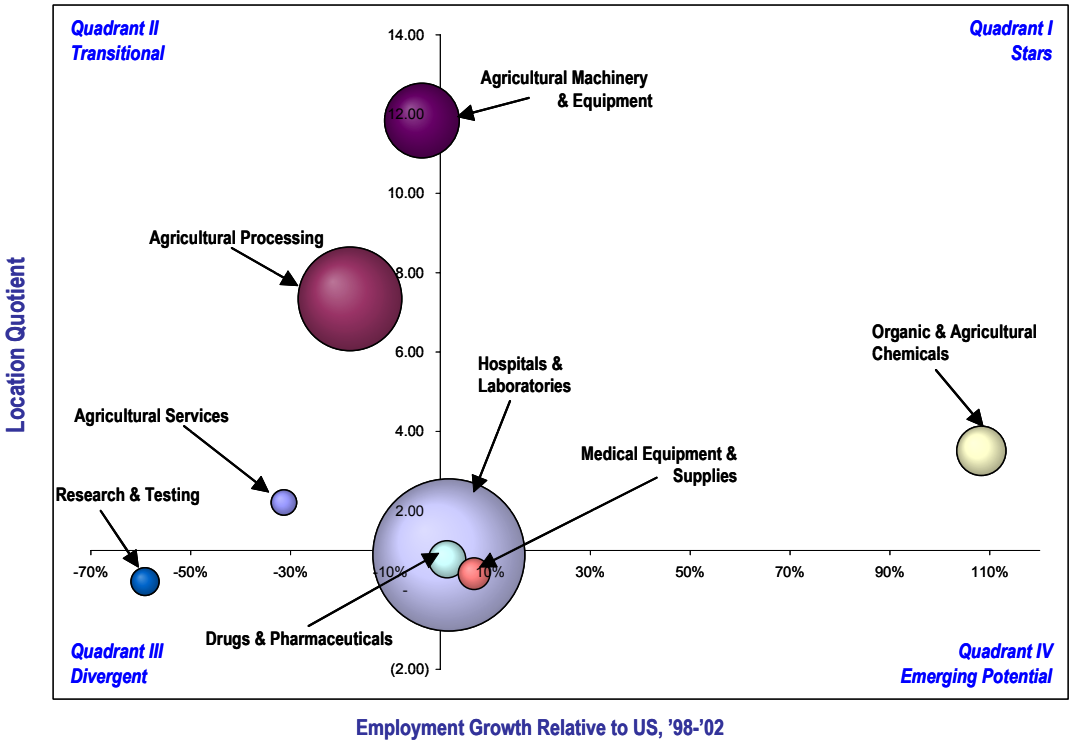
The current level of Iowa's bioscience employment concentration is considered to be regionally specialized. The fact that bioscience employment in Iowa accounts for a larger share of private sector employment than the industry does at the national level results in an above-average location quotient for Iowa. Overall, the state possesses a regional specialization in the bioscience industry that is 24 percent more concentrated than the nation's.

Iowa's Bioscience Cluster Subsectors

Iowa's bioscience subsectors can be categorized into four classes— stars, emerging potential, transitional, and divergent—based upon their growth relative to U.S. growth and their location quotients from 1998 to 2002 (Figure SR-2). Subsectors classified as stars are those that possess significant regional specialization and growth rates exceeding national levels. Emerging potential subsectors are those that are growing more rapidly than the industry at the national level and that present the opportunity to develop a

concentration if rapid growth continues. Subsectors classified as transitional or divergent are not keeping pace with national growth trends. Though the 4-year trend is not irreversible, these subsectors demonstrate current characteristics that may threaten the long-term viability of the industry base in Iowa.

Figure SR-2: Iowa Bioscience Subsector Performance, 1998–2002



Note: Bubble size indicates the subsector employment size.
Source: Battelle calculations based on ES-202 data from the U.S. Department of Labor's Bureau of Labor Statistics and Iowa Workforce Development's Employment Statistics Bureau.

The bioscience industry is a strong driver for the U.S. and Iowa economies, diversifying the economic base; offering good, well-paying jobs; and contributing to overall economic productivity.

Summary and Conclusions

Key conclusions from the economic analysis of Iowa's current economic base include the following:

1. The bioscience industry is a significant contributor to the Iowa economy. In 2002, bioscience employment accounted for 7.0 percent of total employment in Iowa, exceeding the national average of 5.6 percent of total private-sector employment.

2. Iowa's bioscience industry is diverse, with subsectors that are growing rapidly. Iowa has a significant concentration in the organic and agricultural chemicals subsector that is growing rapidly. The drugs and pharmaceuticals and medical equipment and devices subsectors also are growing rapidly. Finally, Iowa has a mature base in the biosciences represented by the number of subsectors in which Iowa is considered to be specialized, including agricultural equipment and machinery, agricultural processing, and agricultural services.

3. The bioscience industry is a tremendous source of well-paying jobs. Compared with other major Iowa industries, the bioscience industry is one of the highest paying in the state. The average wage of a bioscience worker in 2002 exceeded the statewide average annual wage by more than $12,700 and surpassed wages in such sectors as manufacturing; information; construction; and finance, insurance, and real estate. Because the bioscience industry is diversified, comprises a substantial share of state economic activity, and is a source of high-paying jobs, it is reasonable to support initiatives that focus on it.

IOWA'S BIOSCIENCE R&D BASE

Without a strong bioscience research foundation, it is difficult for any state or region to initiate or sustain major industry development related to the biosciences. Universities are the primary leaders in basic and applied bioscience research. Furthermore, research centers are not only essential to the basic research discoveries that generate product leads for bioscience companies, but also contribute to an environment in which these bioscience companies can flourish. University research centers can be a key asset for the bioscience industry in bridging the gap between basic and applied research.

In identifying core research focus areas in the biosciences, the objective is to identify those fields with a critical mass of ongoing activity and measures of excellence. Core research focus areas are identified using both quantitative and qualitative methods, which for this study included extensive field interviews with more than 360 key administrators, scientists, and researchers across Iowa.

With $439.8 million in research funds, Iowa ranks 24th in total university R&D funding (according to the National Science Foundation)—notably exceeding its population rank of 30th. Within the academic R&D arena, the state is performing particularly well in the biosciences, with 66 percent of all academic research funds falling under this definition. This level of performance places Iowa 21st in the nation. Also, Iowa ranks better than its population base in the three major macro-categories of bioscience R&D, ranking 19th in medical sciences, 20th in agricultural sciences, and 22nd in biological sciences. However, given Iowa's agricultural base, its ranking in agricultural sciences is a matter of some concern.

OPPORTUNITIES FOR BIOSCIENCE DEVELOPMENT IN IOWA

Core Platforms for Iowa's Bioscience Development

From analysis of peer-reviewed grant activity, publications activity, and interviews with university deans, faculty, and researchers, Battelle has identified six short- or near-term "platforms" that hold potential for the development of the biosciences in Iowa. These include the following:

- **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 Good Manufacturing Practice(s) production into an integrated pipeline of new drugs and therapeutics.
- **Advanced Food and Feed 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 and genomics expertise to establish a leadership position in the modeling of animal systems and in the development of technologies and applications for genes, genetic markers, 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, and human health and safety.

These six areas represent broad platforms upon which a significant R&D base, business base, and bioscience economy may be built in Iowa in the near to short term. They each specifically draw upon Iowa's institutional expertise in multiple fields, because multidisciplinary research increasingly is gaining importance in driving funding, new study areas, technologies, discoveries, and commercializable innovations. In each case, the analysis shows that these platforms match well with large and rapidly growing projected domestic and international markets. In most cases, the markets are characterized in terms of having expanding multibillion-dollar existing and emerging potential.

In addition to the broad technology platforms, biomedical imaging is a niche platform offering an opportunity for development in the near term. Four emerging, longer-term opportunity areas representing potential for additional sector development include

- **Host-Parasite Biology and Systems;**
- **Instrumentation, Devices, and Sensors;**
- **Formation of a Cardiovascular Research Institute; and**
- **Formation of a Free Radical Research Institute.**

It should be noted that the list of near-term competencies will need to be nurtured and developed over the long term as well. In addition, other cross-cutting, enabling technologies (such as bioinformatics) will affect the potential for these platforms, and investments will need to be considered.

IOWA'S COMPETITIVE POSITION IN THE BIOSCIENCES

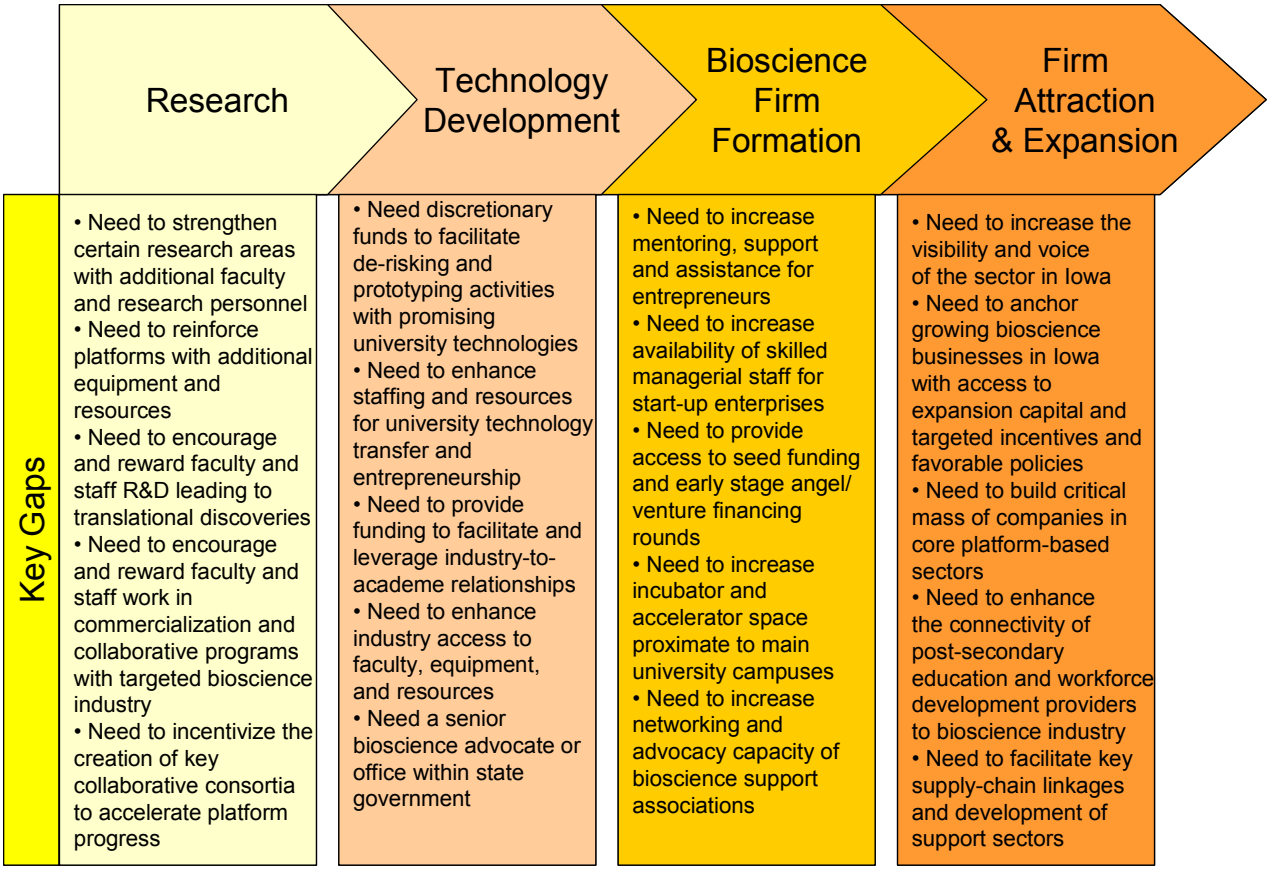
Further investigation of Iowa's position in the biosciences and bioscience-based economic development was accomplished through the use of a SWOT (strengths, weaknesses, opportunities, and threats) analysis. This analysis was accomplished through one-on-one interviews, small group discussions, and focus groups involving leaders throughout the state.

STRATEGIES AND ACTIONS

Gap Analysis

Conclusions from the SWOT analysis drove the identification of key issues that need to be addressed for Iowa to achieve its mission and accomplish its bioscience economic development vision. These issues represent gaps in creating an integrated, wealth-generating continuum that begins with R&D and culminates in full-scale and ongoing bioscience business operations. Figure SR-3 summarizes the key gaps that must be addressed to realize Iowa's bioscience development potential.

Figure SR-3: Iowa's Key Gaps Along the Biosciences Development Continuum



Strategies and Actions

For biosciences to realize their potential as a major economic engine for Iowa, the state must simultaneously address both the strengthening of research drivers and the efficient development of commercial enterprise from research innovations. Four strategies and 20 associated actions have been identified to further develop Iowa's bioscience research base and build a critical mass of bioscience companies.

- **Strategy One:** Build Iowa's bioscience research capacity around selected technology platforms focusing on investments in talent, facilities, and equipment.
- **Strategy Two**: Encourage and facilitate the commercialization of bioscience R&D to enhance opportunities for start-up, emerging, and existing Iowa firms.
- **Strategy Three**: Foster a business environment that supports, sustains, and encourages the growth and sustainability of bioscience firms in Iowa.
- **Strategy Four**: Invest in and develop Iowa's bioscience talent pool.

These strategies and associated actions are summarized in Table SR-1. Implementation of these strategies and actions is anticipated as a 5-year period. *Immediate* priorities should be undertaken in the next year to 18 months, *short-term* priorities should be undertaken in 18 months to 3 years, and *mid-term* priorities in 3 to 5 years.

Table SR-1: Iowa Bioscience Pathway Strategies and Actions

Strategy	Actions	Priority
Strategy One: *Build Iowa's bioscience research capacity around selected technology platforms focusing on investments in talent, facilities, and equipment.*	▪ **Undertake key recruitment, capacity building, and required investments to ensure rapid scientific progress in the core bioscience platforms.**	Short-term
	▪ Create an **Endowed Chairs Program** to attract world-class, entrepreneurial talent in the core bioscience platforms.	Short-term
	▪ Form a **Strategic Technology Platform Infrastructure Fund** to strengthen and accelerate the scientific and commercialization work of the core bioscience platforms.	Short-term
	▪ **Engage Iowa's Congressional Delegation** in discussions pertaining to federal funding and specific project support.	Immediate
	▪ Institute an industry-university **matching grant program dedicated to the identified bioscience technology platforms** to encourage relationships between academic researchers and industry.	Immediate
Strategy Two: *Encourage and facilitate the commercialization of bioscience R&D to enhance opportunities for start-up, emerging, and existing Iowa firms.*	▪ **Create and Fund an Economic Development Director position at the Iowa Board of Regents** to provide catalytic support for regent university economic development initiatives.	Immediate
	▪ Develop and implement policies and procedures that actively **encourage faculty entrepreneurship and commercialization activities** at the regent universities.	Immediate
	▪ **Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.**	Immediate
	▪ Establish and fund a **University Entrepreneurs Center** at each university.	Short-term
	▪ **Form a statewide commercialization intermediary** for supporting, building, and sustaining development of new bioscience business enterprises in Iowa.	Immediate

Table SR-1: Iowa Bioscience Pathway Strategies and Actions (continued)

Strategy	Actions	Priority
Strategy Three: *Foster a business environment that supports, sustains, and encourages the growth and sustainability of bioscience firms in Iowa.*	▪ **Form the Iowa Bioscience Alliance** to facilitate communications, foster joint approaches to issues, and develop a critical mass of support to stimulate actions required to realize Iowa's bioscience vision.	Short-term
	▪ **Establish a State Bioscience Advocate** position, reporting to the Director of IDED, to drive the implementation of this strategy.	Short-term
	▪ **Implement Iowa's bioscience image and brand** through aggressive marketing, public relations, and signature events.	Immediate
	▪ **Review and make necessary changes to state incentives (including the Iowa Values Fund), tax policies, and legal code** to be responsive to the needs of growing bioscience firms.	Short-term
	▪ **Conduct an economic impact study** to measure the projected returns to the state and its regions that are estimated to result from proposed bioscience investments. The study should pay special attention to geographic equity and the diffusion of innovation benefits throughout the state.	Short-term
	▪ **Develop a training program for state and local economic development professionals** that would include information on university bioscience technology platforms and technical capabilities, the specialized needs of bioscience companies, and programs and incentives that can be used to assist new bioscience ventures and expanding and/or relocating firms.	Mid-term
Strategy Four: *Invest in and develop Iowa's bioscience talent pool.*	▪ **Improve K-12 scientific education** by focusing on stimulating interest among Iowa's children in science, thereby preparing them for careers in Iowa's growing bioscience sectors.	Mid-term
	▪ Develop a bioscience vocational career education program and **ensure seamless delivery between secondary and community college programs** that serve Iowa's growing concentration of bioscience employers.	Mid-term
	▪ **Streamline bioscience articulation agreements** within and between community colleges and Iowa's regent universities to allow students to transfer credits between academic institutions.	Short-term
	▪ **Leverage alumni associations and the state's Human Resources Recruitment Consortium** to attract to Iowa bioscience professionals, including experienced bioscience managers.	Immediate

IMPLEMENTATION PLAN

Obviously, the biosciences already are an important part of the Iowa economy and show great potential for expanding their positive economic impacts for the state. However, if Iowa is to achieve its vision for the biosciences, it must aggressively implement the strategies and actions outlined in this report. Because the state does not have unlimited resources, it is, of course, important to set priorities. The following section summarizes the critical actions that must be taken to develop Iowa's bioscience sector.

Critical Actions

To realize the full bioscience economic potential that this roadmap lays out, Iowa must successfully implement certain critical actions. Specifically, the ultimate success of the strategy hinges on the forward movement of six activities, in essence Iowa's bioscience critical path. In other words, it is these six critical actions that are most significant to, and the underlying foundation for, the eventual success of this strategy. Therefore, when initial resource allocations are being determined, efforts must be made to ensure that the following critical actions receive funding priority:

- Form a Strategic Technology Platform Infrastructure Fund **to reinforce the core bioscience platforms** by supporting faculty recruitment, entrepreneurial endowed chairs, and other key actions. The fund will be directed through academic consortia set up to develop the six bioscience platforms. Financed perhaps by bonds or other sources, the fund also would provide infrastructure and equipment funding to reinforce the platforms.
- **Develop and implement policies and procedures at the regent universities** to ensure the highest level of encouragement and support for private-sector partnering, commercialization, and entrepreneurship.
- **Form a statewide commercialization intermediary for supporting, building, and sustaining development of new bioscience business enterprises in Iowa**. This organization will proactively assist Iowa's bioscience entrepreneurs, and provide business development services to companies formed from university-based technology transfer and commercialization efforts and from other sources of intellectual capital.
- **Form the Iowa Bioscience Alliance** to serve as a guiding force in engaging industry in the strategy implementation and stewardship. Connect the Alliance to the proposed academic consortia to be formed around the bioscience platforms to ensure industry-university collaboration of platform R&D and commercialization of innovations.
- **Institute an industry-university matching grant program** dedicated to the identified bioscience technology platforms to boost bioscience R&D collaborations between academia and industry in Iowa.
- Increase funding to the regent universities to **allow for sufficient staffing and resources for commercialization activities.**

The above actions will ensure the following: that the strengths of the current core bioscience platforms are leveraged and further built; that industry and academe work together on joint R&D initiatives to develop commercial innovations from each platform; that funding and support are available to develop bioscience entrepreneurs and their business ventures; and that the regent universities are optimally leveraged for the bioscience-based economic development of the state.

Immediate Priorities

Immediate work plan priorities are those steps that should be undertaken in the first 12 months of strategy implementation, regardless of how critical they are to the overall strategy. Several immediate priorities can be implemented right away, while others will need to be planned and allocated funds before they can become fully operational. The following actions should be undertaken in the first year:

- Create and fund an Economic Development Director position on the Iowa Board of Regents to provide catalytic support for regent university economic development initiatives.
- Develop and implement policies and procedures that actively encourage faculty entrepreneurship and commercialization activities at the regent universities.
- Engage Iowa's Congressional Delegation in discussions pertaining to federal funding and specific project support.
- Institute an industry-university matching grant program dedicated to the identified bioscience technology platforms to encourage relationships between academic researchers and industry.
- Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.
- Form a statewide commercialization intermediary for supporting, building, and sustaining development of new bioscience business enterprises in Iowa. The commercialization organization will work to address technology, capital, and talent issues.
- Implement Iowa's bioscience image and brand through aggressive marketing, public relations, and signature events.
- Leverage alumni associations and the state's Human Resources Recruitment Consortium to attract to Iowa bioscience professionals. An initial emphasis should be placed on attracting individuals with experience in bioscience management.

Resource Requirements

For each action, Table SR-2 indicates the priority of the action, breaks down state funding needs into two 5-year phases, and indicates the anticipated external leverage. In addition to the Iowa Bioscience Pathway financial plan detailed in Table SR-2, the proposed revenue sources to be allocated from the state for this financial plan are broken down in Table SR-3. Overall, total costs to the state government in two 5-year phases are $301.6 million, of which $169.8 million is bond financed and $131.8 million is financed through general fund appropriations. State general fund and bond financing investments over a 10-year period are estimated to generate external leverage of more than $1.5 billion, or $5 of outside funds for every $1 invested by the state. Bond financing support is focused on further building Iowa's strengths in its technology platforms and the associated investments found in several actions primarily under Strategy One. Phase I totals $144.2 million, including bond financing of $96.8 million for capacity building of infrastructure, recruitment, and matching support; and $47.4 million in general fund appropriations. In Phase II (years 6 to 10), state funds of $157.3 million would be required, including $73 million in bond financing for further capacity building and $84.3 million in general fund appropriations.

Table SR-2: Iowa Bioscience Pathway Financial Plan

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Capacity building in the key platform areas	Short-term	Consortia: $1.2 M increasing to $2.0 M by year 5 Matching grants: $1.7 M increasing to $3.8 M—this item covered under Infrastructure Fund	Consortia: $2 M per year rising to $5 M by year 10 Matching grants: $3.8 M staying constant years 6-10	$10.188 M annually for first 5 years for platform investments, or $50.94 M from the bond-financed Strategic Investment Fund (see below)	9:1 federal funding leverage based on other state performance
Entrepre-neurial Endowed Chairs program	Short-term	$2 M per year for 3 years and $1M in year 4	Second round of additional chairs: $3 M for 3 years and $1.5 M in year 4		2:1 (match to state funds)
Strategic Technology Platform Infrastructure Fund	Short-term	This Fund supports above actions in capacity building of platforms and endowed chairs as well as matching grants item below and one-time costs of these and prototype fund		$169.44 M capitalization via bonds with $96.76 M in Phase I 5-year period and $73 M in Phase II 5-year period	
Engage Iowa's Congres-sional Delegation for federal funding	Immediate	Existing resources			
Industry-university matching grant program	Immediate	Initial year funding at $1.5 M rising to $3.0 M by year 5	Years 6 through 10 rise from $3.0 M to $5.0 M		3:1 (match to state funds)
Economic Development Director position on the Iowa Board of Regents	Immediate	$150,000 per year	$175,000 per year		

Table SR-2: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Policies and procedures that actively encourage faculty entrepreneurship and commercialization	Immediate	$200,000 per year	$240,000 per year		
Funding to the regent universities for commercialization activities/tech transfer	Immediate	$2.9 M in year 1 increasing to $9.55 M in year 5 Mining: start at $300,000 and increase to $600,000 by year 5 TT: start at $1.5 M and increase to $5.8 M by year 5 Business develop-ment : start at $300,000 and increase to $750,000 by year 5 Industry liaison: start at $300,000 and increase to $1.2 M by year 5 Marketing and communications: start at $500,000 and increase to $1.2 M by year 5	Increase by 10% per year or: Year 6: $10.5 M Year 7: $11.55 M Year 8: $12.71 M Year 9: $13.98 M Year 10: $15.38 M	$1 M to be covered as infrastructure funds from Strategic Infra-structure Fund	6:1 leveraged return in increased sponsored research, licensing revenue, and equity in start-ups
Establish a University Entrepreneurs Center	Short-term	$450,000 per year	Years 6 and beyond increase to $600,000 per year		

Table SR-2: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Form a statewide commercialization intermediary	Immediate	$1 M year 1 $1.5 M year 2 $2 M years 3, 4, and 5	Years 6 and beyond increase to $2.2 M per year	$3 M to $5 M Prototype Development Fund over first 5 years and similar amount for years 6-10 financed by Infrastructure Fund $25 M to $50 M initial capitalization for BioSeed Fund as part of Fund of Funds (nondirect state) and privately financed thereafter	Leveraged 6:1 return in private funds, sales, and other income
Form the Iowa Bioscience Alliance	Short-term	$400,000 in year 1 decreasing in year 5 to $100,000	Ongoing support in years 6 and beyond of $100,000 per year		Leverage 3:1 private, university, and other funds
Establish a State Bioscience Advocate position	Short-term	$125,000 in year 1 increasing to $175,000 in year 5	$200,000 in year 6 increasing to $300,000 in year 10		
Implement Iowa's bioscience image and brand through aggressive marketing	Immediate	As currently budgeted IDED			
Review and make necessary changes to state incentives, tax policies, and legal code	Short-term			$100,000 for study and review in year 2	
Conduct an economic impact study for bioscience strategy	Short-term			$100,000 for study and review in year 1	

Table SR-2: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Develop a biosciences-development training program for state and local economic development professionals	Mid-term	$470,000 for UNI's IDM operations funded (currently they are at $280,000) beginning in years 2 through 5	Maintain funding at $470,000 per year in years 6 through 10		
Improve K-12 scientific education	Mid-term	To be determined			
Provide articulation agreements between K-12 and community colleges in bioscience education	Mid-term			$500,000 in year 3	
Streamline bioscience articulation agreements within and between community colleges and universities	Short-term	Existing resources			
Leverage alumni associations and the state's Human Resources Recruitment Consortium	Immediate	Existing resources			

Table SR-3: Financial Plan by Year and Proposed Sources of Revenue (state funds only—dollars in millions)

Year	Total State Investments	Bond Financed	General Fund Support
1	21.913	16.588	5.325
2	30.193	22.633	7.530
3	29.878	19.738	10.140
4	30.158	18.813	11.345
5	32.083	18.988	13.095
Subtotal Year 1-5	$144.225	$96.76	$47.435
6	26.685	12.200	14.485
7	33.930	18.350	15.580
8	31.265	14.500	16.765
9	32.195	14.150	18.045
10	33.265	13.800	19.465
Subtotal Year 6-10	$157.340	$73.000	$84.340
Grand Total	**$301.565**	**$169.76**	**$131.775**

Organization and Structure

State science and technology initiatives are most effective when they are executed on a bipartisan basis, with strong executive and legislative branch support, involvement, and cooperation. States such as Pennsylvania, New York, Maine, Maryland, and North Carolina have been successful with their science and technology investments because their efforts have been broad based, they have mobilized private sector champions behind them, and their initiatives have become institutionalized into both economic development and higher education at state and regional levels.

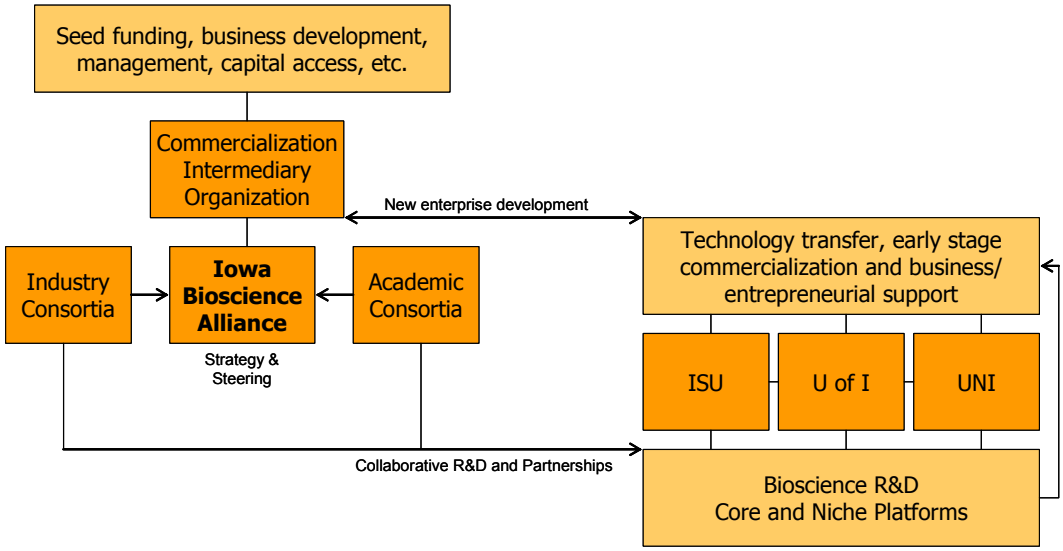
The following deficiencies indicate that Iowa is less than optimally organized to develop its bioscience-based economy:

- No Science and Technology Office, Science and Technology Advisor, or Bioscience Advocate at the state government level. As a result, policies are more likely to be enacted in an *ad hoc* fashion, rather than following a formal strategic plan and pathway.
- No economic development function coordinated at the level of the Iowa Board of Regents. Thus, the individual universities hold sole responsibility for setting strategy and actions.
- Declining funds to support regent university economic development, technology transfer, and commercialization activities. With budget cuts of more than 60 percent in the past 3 years, the regent universities have seen their organizational capacity in these key functions drastically reduced.
- Small and comparatively under-resourced bioscience-related industry organizations (such as the Iowa Biotechnology Association and BIOWA). Therefore, the services and bioscience development initiatives they can undertake are limited.
- No clear organizational and assistance structures for would-be bioscience entrepreneurs to follow in terms of accessing business development assistance, prototype development and pre-seed/seed funding, management talent, expansion capital, etc.

To help solve these organizational deficiencies, the Iowa Bioscience Pathway proposes a set of strategies and actions that involve multiple public and private organizations and entities. These strategies and actions have been designed to build on the base of organizational capabilities that currently exist in Iowa and to provide resources and actions that create a structure for filling critical gaps.

Directing and administrating the implementation of the Iowa Bioscience Pathway are critically important functions. Given the important role that industry, academe, and government each must play, it is imperative that an organization be structured that will engage each of these groups in the process. The logical convening entity would be the Iowa Bioscience Alliance (as shown in Figure SR-4). The Alliance, staffed and financially supported by the Iowa Department of Economic Development, would be a formal collaboration between industry and academe. Industry and academic consortia, established for each bioscience platform, would be the core constituent components of the Iowa Bioscience Alliance, working to advance applied bioscience R&D in the state. In addition, it is proposed that the commercialization intermediary organization directly report to the Alliance.

Figure SR-4: Basic Organizing Structure of Iowa Bioscience Development



Measures of Success and Accountability

The following measures and performance goals, to be monitored on an ongoing basis by the Iowa Bioscience Alliance, should be used to determine the successful accomplishment of performance objectives:

- There will be more than 130 new bioscience business start-ups in Iowa by 2014.
- Iowa's location quotient in all the biosciences will exceed 1.4 to 1.5 by 2008, compared with 1.24 in 2002.
- Iowa will increase its university R&D funding (primarily from federal sources) for bioscience-related research from $291 million in 2001 to $700 million by 2010 and more than $900 million by 2014.
- The state will leverage at least $5 in federal and other dollars for every $1 of state support.
- There will be substantial implementation progress on the actions outlined in this pathway – at least 70 percent will have substantial action after 3 years and 90 percent within 5 years.

10-Year Economic Impact

The state's proposed investment of $302 million in bond financing and general fund support over the next 10 years will leverage an estimated $1.5 billion in federal, industry, and other funds. This level of investment is projected to translate into more than 5,100 private sector jobs through new and relocated firms, as well as an additional 10,950 private sector jobs from an indirect multiplier impact on other industries and businesses, for a total projected impact of 16,050 jobs by the year 2014. These numbers likely will increase substantially in a 15- to 20-year period as the exponential impact multiplies again and again. Total sales in year 10 are projected at nearly $1.4 billion.

Although it takes considerable time for state and private investments to have measurable impacts on a state economy, it is important to note that the overall economic impacts surely will include some that cannot be projected such as additional increases in direct university employment and retained private sector jobs with higher skills and better pay.

CONCLUSION

Iowa has the opportunity to build its economy through the application of advanced biosciences. Indeed, given the state's agricultural-bioscience expertise, its leading-edge work in biorenewables, and its distinct strengths in various areas of human and animal medicine, the biosciences represent the most logical path to a high-productivity, high-wage, 21st century economy. Iowa already is beginning to see distinct progress around advanced areas of bioscience; but, a definite opportunity exists to accelerate the process and optimize the growth of the sector in the state.

This pathway for development lays out a detailed approach to accomplishing bioscience-based economic development in Iowa. The strategy puts forward a bioscience agenda that effectively integrates the private, public, and academic sectors in Iowa into a unified driving force for development centered on Iowa's bioscience platform strengths. In addition, the pathway seeks to leverage the significant momentum that already has been built through the state's investments in programs such as the Iowa Values Fund.

However, for Iowa to succeed in achieving its bioscience vision, the state must take a comprehensive approach that addresses each of the key recommendations in this strategy. Strengthening Iowa's bioscience research infrastructure will result in jobs and income for the citizens of Iowa only if research findings are commercialized and new companies created based on technological innovation. Similarly, for commercialization to be successful, there must be a steady pipeline of discoveries. To retain and grow bioscience firms, firms must feel that Iowa supports them in its policies and regulations. And lastly, if Iowa's economy is to benefit from innovation in the biosciences, the state must have a talent pool ready to fill the new jobs created in bioscience companies. A comprehensive and integrated approach is needed for Iowa to become a significant player in the biosciences.

Iowa's Bioscience Pathway for Development

Technical Report

Battelle
The Business of Innovation

Introduction

Iowa, like many Midwestern states, finds itself at a challenging time in its history. A declining manufacturing base and an increasingly competitive worldwide agricultural market threaten the traditional economic prosperity and high standard of living that Iowans and others in the Midwest have come to expect.

To sustain the comparatively high wages that Americans enjoy, the nation has to work to attain ever higher levels of productivity by adopting advanced technologies and educating a workforce skilled in deploying, operating, and leveraging that technology (whether in manufacturing, services, agricultural production, or other sectors of the economy). The sustainability of this economic model depends upon a well-educated and skillful population and consistent progress through technological innovation. As talent and technology increasingly drive the ability of states to create wealth, there are likely to be winners and losers among the states. Multiple knowledge economy growth poles have emerged in the United States in places such as Silicon Valley, San Diego, Boston, Seattle, North Carolina, Maryland, and Austin. These locations have brought together the critical mix of talent, technology and capital to facilitate an economy driven by innovation, an economy able to sustain high levels of economic performance in an increasingly competitive global market, a "new economy."

The U.S. economy always has been nourished by inventiveness and creativity, so the "innovation economy" *per se* is not new; rather, innovation has become the primary impetus of economic growth and competitiveness among regions and developed nations. Two fundamental forces are driving technology and knowledge advancement as determinants of economic success:

- The rapidly accelerating pace of scientific discoveries and the technologies that are developed from these discoveries. For example, advances in genetics have accelerated dramatically the discovery process in the biosciences. The opportunity to accelerate the discovery and development processes, along with the ability to protect and profit from intellectual property, has led to an innovation race among competing countries, regions, and states.
- Global world markets and increasing pressure on the United States to maintain its high-wage, high-skill employment base through technology gains and productivity increases.

To be secure and sustainable in its economic future, Iowa must join the ranks of states committed to leveraging their know-how and creativity to create economic platforms in technology-driven fields. Through research and development (R&D), innovation, and the commercialization of innovation, a positive economic future may be secured. The biosciences represent one of those fields.

In recent years, considerable attention has been paid in state economic development circles to the importance of the biosciences as an engine for innovation and technology growth in the 21st century. Many states have developed bioscience plans, mostly focused on applying bioscience to human biomedical products (primarily research and testing and, in rarer cases, pharmaceuticals and diagnostics, medical devices, instruments, and replacement tissue). While applying bioscience to human health holds significant economic potential, so too does applying bioscience to animal and plant sciences—including agricultural productivity, agricultural and food products, livestock and companion animal health, new engineering materials, and chemicals and biologics developed via biomass pathways. The plant and animal biosphere contains a huge repository of genes; the novel combination, mining, and use of which have the potential to stimulate change in a broad range of industries, from medicinal and food products to

advanced manufacturing industries such as materials and energy sources. Traditional bioscience and bioengineering disciplines also have a great deal to contribute in new production and processing technologies, improved products from agricultural commodities and biological materials, and the novel application of bioresources to as-yet undiscovered economic uses.

Given the economic prospects contained within the rapidly advancing bioscience sector, it is not surprising that multiple states should seek to identify and leverage their core bioscience competencies. The presence and ongoing operation of bioscience research and development institutions in a state likely can provide a comparative advantage for growing and diversifying an economy along one of many paths.

Iowa, as this report will detail, has the opportunity to become a significant player in the bioscience-driven economy. Iowa comes to this path with considerable strengths. It is home to two major bioscience research universities (Iowa State University [ISU] and the University of Iowa [U of I]), with supplemental expertise provided by the University of Northern Iowa (UNI). In addition to its academic strengths, Iowa is home to a diverse range of bioscience industry, incorporating agbiosciences, traditional biotechnology, pharmaceuticals, medical devices, and various additional sectors.

A significant portion of these advances in Iowa's bioscience-based economy can be directly attributed to the initiatives of the state's leaders. In 2001, Governor Vilsack launched a statewide technology cluster initiative that identified three areas of focus: biosciences, advanced manufacturing, and information solutions. Furthering this effort, in 2003 the Iowa Legislature approved the Iowa Values Fund, a 7-year, $503 million state investment in the three cluster areas. The goals of this fund are to help move and grow Iowa's economy, create jobs, and help generate wealth for Iowans. The Iowa Values Fund is composed of four main components:

- Business development and assistance
- University research and development
- Workforce training
- Quality of life.

Iowa also has focused significant programmatic investments to develop tax incentives for research and development, to help universities turn research into business opportunities, and to create venture capital funding to aid business start-ups. For instance, during its 2002 session, the Iowa Legislature enacted an economic stimulus measure designed to encourage private venture capital investment in emerging, expanding, and restructuring business enterprises in communities throughout Iowa. To facilitate the goals set forth in the Act, the Legislature authorized the formation of the Iowa Capital Investment Corporation (ICIC) for the purpose of mobilizing tax credits to incentivize private venture capital investments. ICIC's primary purpose is to organize and manage the Iowa Fund of Funds (Fund of Funds). The Fund of Funds is a private, for-profit limited partnership authorized to make investments in private venture capital funds. To facilitate private investment in the Fund of Funds and minimize the need for public appropriations, the Legislature also authorized the issuance of contingent tax credits to guarantee, at least partially, investments in the Fund of Funds. The Iowa Capital Investment Board (ICIB) oversees the issuance of the tax credits contingent on certain ICIB-developed criteria. Tax credits totaling $982,000 of the total $10 million available have been issued to date related to the 20 percent credit for qualifying businesses and community-based seed funds. Also, credits totaling $644,000 of the total $5 million available have been issued related to the 6 percent credit for qualifying venture capital funds.

While these investments are sizeable, the race among states to establish leadership positions in bioscience fields has already started, and the window of opportunity for Iowa to invest the resources necessary to

leverage its strengths and become a significant player in the leading sector of the 21st Century economy will not remain open indefinitely. The state has to understand its strengths, offset its weaknesses, and make highly strategic private and public investments to leverage its core bioscience competencies into a sustainable bioscience-driven economic sector.

To facilitate an in-depth understanding of core bioscience opportunities and to develop a strategy for building the Iowa bioscience economy, the Iowa Department of Economic Development (IDED) engaged Battelle's Technology Partnership Practice (TPP) to develop a state bioscience strategy and pathway in a two-phase effort:

- **Economic and core competency analyses of the biosciences in Iowa**. This Phase I work was released March 2004 in the report entitled, *The State of Iowa Biosciences Path for Development: Economic and Core Competency Analyses*. In this report, Battelle examined the current quantitative position of Iowa in commercial bioscience sectors and in academic bioscience R&D and produced a formal assessment of core competencies and fundamental strength platforms upon which Iowa's bioscience economy may be built.
- **A strategy and actions roadmap** or pathway (Phase II) for the state that provides specific guidance in bioscience-based economic development.

To complete both Phases I and II assignments, Battelle used both quantitative and qualitative techniques, including more than 500 face-to-face interviews with representatives of industry, academe, government, and other stakeholder organizations in Iowa.[4] Meeting the key goals for the projects required that Battelle

- Conduct an economic analysis of Iowa's existing bioscience industry, identifying trends, current strengths, emerging industries, and emerging clusters within the biosciences;
- Assess Iowa's position in bioscience research and provide a detailed understanding of the bioscience core competencies that form platforms for future bioscience development;
- Identify key barriers and gaps in private and public investments, policies, programs, and activities that negatively impact Iowa's ability to realize its development potential from the biosciences;
- Outline a series of specific strategies and actions designed to fill in the gaps and maximize the economic advantage of Iowa's core bioscience strengths; and
- Provide an implementation plan, showing action priorities, estimated resource requirements, and an organizational structure for moving the roadmap forward.

The findings, conclusions, and recommendations of the strategy and actions roadmap are the subject of this report. Pertinent aspects of the economic and core competency analyses from Phase I also are included so that this report can serve as a standalone document for the state. In the process of completing the roadmap, further adjustments to the Phase I analyses were made; these have been incorporated into this document.

This strategy begins with an analysis of Iowa's bioscience base, examining the current state of its industrial core as well as the strength of its research activities. This leads to a summary of the Phase I core competency findings. Key strengths, weaknesses, opportunities, and threats as they relate to bioscience-driven economic-development are summarized. Further, this report puts forth a vision and mission for bioscience development in the state and provides a situational analysis in which challenges

[4] Many individuals were interviewed for both Phase I and Phase II of this analysis.

and gaps related to the realization of this vision are examined. Specific strategies and actions are then proposed that will serve, if acted upon, to facilitate realization of the vision through leveraging existing organizations and programs and developing new initiatives. To the extent feasible, actions proposed in this Plan take advantage of and utilize existing institutions and organizations whenever possible. An implementation plan is also put forward to provide critical guidance to the state and key stakeholder institutions in moving Iowa into a strong leadership position in bioscience development.

Iowa's Bioscience Base

In considering the base of a state or region's bioscience activity, two dimensions are critical—the level of industrial development and the bioscience research base. A strong bioscience R&D base is critical to the development of a state's or region's bioscience sector given the close relationship between basic research discoveries and product development in this industry sector. Major new products and innovations in the biosciences are frequently related to basic research discoveries; whereas, in other technology sectors, the links are less direct. To assess Iowa's current competitive position and to identify those bioscience niches in which the state has strengths, Battelle examined the state's existing bioscience industry sector and bioscience R&D base.

IOWA'S BIOSCIENCE INDUSTRY SECTOR

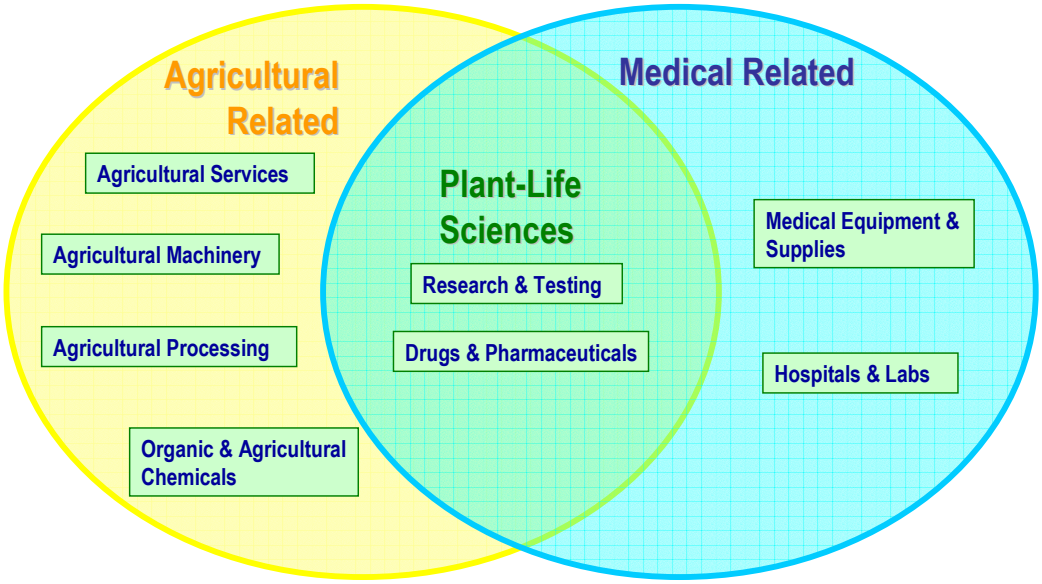
What Industries Constitute the Biosciences?

Varying industrial classifications could be used to define the bioscience sector of the economy. Currently, there is no commonly accepted definition. Categorization is difficult because of the diversity of bioscience activity. The industry is dynamic and encompasses a wide variety of industrial applications. Continual innovation further complicates the industry definition. Bioscience advancements constantly are being applied in new and different ways, creating new industry segments, such as genetically improved foods, or alternate energy sources, such as agriculturally based fuels.

This analysis addressed the diversity of the bioscience industry by dividing it into three sectors: agricultural, medical, and plant-life sciences. The agricultural sector consists of those industrial subsectors involved in developing, supporting, and manufacturing new farming and food production technologies for advancing health and nutrition. The medical sector consists of those industrial subsectors involved in manufacturing and developing clinical techniques aimed at and directed toward advancing human health care. The plant-life sciences sector consists of those industrial subsectors involved in research, testing, developing, and manufacturing clinical and agronomic techniques and products for improving the functions of living organisms.

These three sectors can be further delineated into eight subsectors (Figure 1). Each subsector of bioscience activity encompasses a wide variety of industrial activity in which Iowa is well situated to further build and strengthen its overall bioscience base.

Figure 1: Broadly Defined Iowa "Bioscience" Industry



Iowa's Bioscience Cluster

Recent employment trends since 2000 indicate a growth rate that is above the national average. In Iowa, the bioscience industry experienced above-average employment growth between 2000 and 2002, growing by 5.3 percent and gaining 4,179 jobs. In 2002, the Iowa bioscience industry employed 82,849 individuals across 1,856 establishments. Overall, the industry has demonstrated above-average growth since 2000, despite the economic downturn that began in March 2001.[5]

Even more promising is that this growth rate was above the national average. The bioscience industry across the United States grew at a rate of 3.7 percent between 2000 and 2002. Table 1 illustrates the bioscience industry's overall performance in Iowa and the nation.

The bioscience industry also represents a sizable portion of Iowa's economy. Bioscience employment concentrations over the same time period consistently accounted for a larger share of state private-sector employment than at the national level. In 2002, bioscience employment in Iowa accounted for 7.0 percent of total state private-sector employment. Nationally, the bioscience industry accounted for 5.6 percent of total private-sector employment.

[5] The National Bureau's Business Cycle Dating Committee maintains a chronology of the U.S. business cycle. The chronology identifies the dates of peaks and troughs that frame economic recession or expansion. The period from a peak to a trough is a recession, and the period from a trough to a peak is an expansion. According to the chronology, the most recent peak occurred in March 2001, ending a record-long expansion that began in 1991. The most recent trough occurred in November 2001, inaugurating an expansion. http://www.nber.org/cycles/november2001/recessnov.html.

Table 1: State and National Bioscience Comparison, 1998–2002

Metric		IOWA		UNITED STATES	
		Biosciences	Total Private Sector	Biosciences	Total Private Sector
Establishments					
	2000	1,951	98,845	81,772	7,697,470
	2002	1,856	83,340	86,273	7,852,549
% Change	00-02	-4.9%	-15.7%	5.5%	2.0%
Employment					
	2000	78,670	1,217,722	5,855,230	108,358,433
	2002	82,849	1,185,668	6,072,130	107,618,787
% Change	00-02	5.3%	-2.6%	3.7%	-0.7%
Employees per Establishment					
	2000	40	12	72	14
	2002	45	14	70	14
Location Quotient					
	2000	1.20	n.a	n.a	n.a
	2002	1.24	n.a	n.a	n.a
Wages					
	2000	36,127	27,570	41,165	35,470
	2002	39,253	29,158	44,199	36,517
% Change	00-02	8.7%	5.8%	7.4%	3.0%
Percent Share of Private Sector of Employment					
	2000	6.5%	n.a	5.4%	n.a
	2002	7.0%	n.a	5.6%	n.a

Iowa Workforce Development, Employment Statistics Bureau

The current level of Iowa's bioscience employment concentration is considered to be regionally specialized. The location quotient is a common measure of the concentration of an industry within an economic region. When the concentration is significantly above average, a location quotient above 1.20, the region is said to possess a specialization in the industry. The fact that bioscience employment in Iowa accounts for a larger share of private sector employment than the industry does at the national level results in an above average location quotient for Iowa. Applying the formula in Figure 2 indicates that Iowa possesses a regional specialization in the bioscience industry that in 2002 was 1.24, an increase from 1.20 in 2000.[6]

Figure 2: Location Quotient Formula

$LQ_{Ri} = (R_i / R_T) / (US_i / US_T)$

Where:

R_i = industry *i* employment for the region

R_T = total employment for the region

US_i = industry *i* employment for the nation

US_T = total employment for the nation

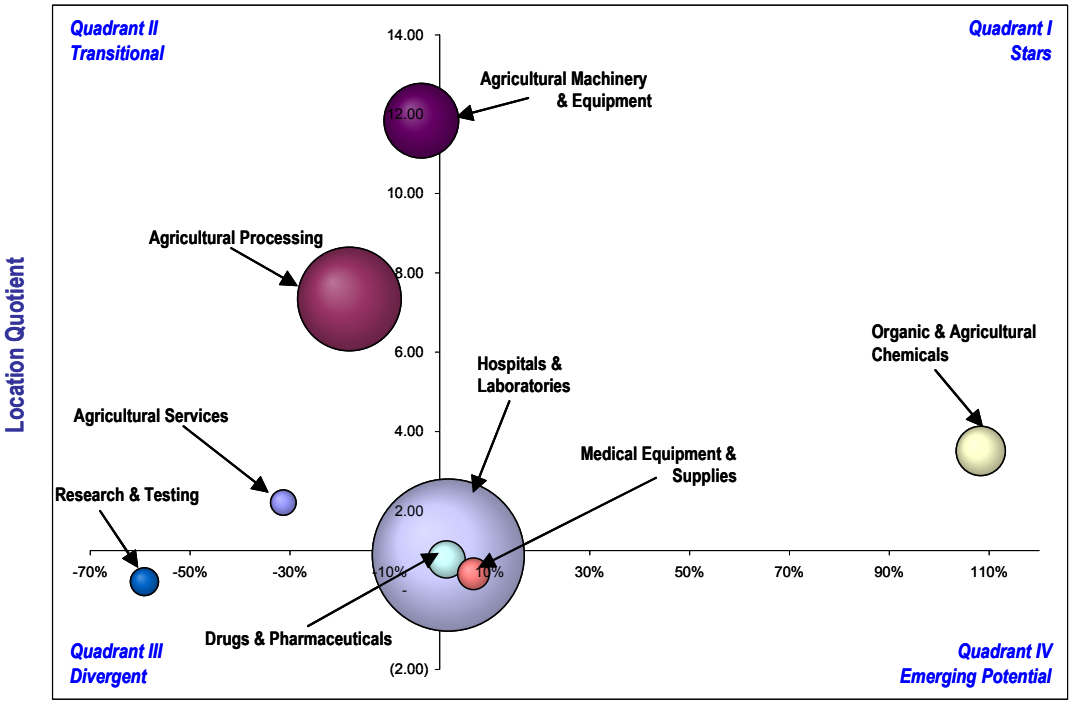
[6] Location quotients are a common measure of the concentration of a particular industry in a region relative to the nation (reference area). The LQ consists of the ratio of the share of total regional employment that is in the particular industry and the share of total employment in the nation (reference area) that is in the particular industry. An LQ greater than 1.0 for a particular industry indicates that the region is relatively concentrated, whereas an LQ less than 1.0 signifies a relative under-representation. A location quotient of above 1.20 denotes employment concentration well above the national average. Throughout this report, LQs are used to report regional industry concentrations relative to the United States as a whole. The minimum concentration threshold for declaring a regional specialization is a matter of judgment and varies somewhat in the relevant literature. In this analysis, regional specializations are defined by LQs of 1.2 or greater.

Iowa's Bioscience Cluster Subsectors

Iowa's bioscience cluster includes eight individual subsectors. Each subsector specializes in distinct aspects of the biosciences and contains its own value chain and set of supply relationships. Cross-cutting relationships also exist among and between the subsectors. Accurately depicting Iowa's bioscience industry requires examining each of these unique subsectors. Dissecting the industry also helps identify specific areas of strength and opportunity to create synergies and facilitate future development potential for the entire industry sector.

Iowa's bioscience subsectors can be categorized into four classes—***stars, emerging potential, transitional, and divergent***—based upon their performance from 1998 to 2002, as shown in Figure 3. The four categories are based on (1) the subsector's growth relative to U.S. growth and (2) the subsector's location quotient. Subsectors classified as stars are those that possess significant regional specialization and growth rates exceeding national levels. Emerging potential subsectors are those that are growing more rapidly than the industry at the national level and that present the opportunity to develop a concentration if rapid growth continues. Subsectors classified as transitional or divergent are not keeping pace with national growth trends. Though not irreversible, these subsectors demonstrate current characteristics that may threaten the long-term viability of the industry in Iowa.

Figure 3: Iowa Bioscience Cluster Subsector Performance, 1998–2002



Note: Bubble size indicates the subsector employment size.
Source: Battelle calculations based on ES-202 data from the U.S. Department of Labor's Bureau of Labor Statistics and Iowa Workforce Development's Employment Statistics Bureau.

Stars

The organic and agricultural chemicals subsector is the fastest growing subsector in Iowa relative to the United States and is regionally specialized. The subsector had an employment base of 4,416 in 2002 across 56 establishments. This employment increase is substantial considering that, at the national level, the subsector experienced a 15.3 percent employment drop. The phenomenal growth in Iowa has positioned the subsector well above the national employment concentration level.

The state's employment concentration in organic and agricultural chemicals is 2.5 times greater than the national average. This level of employment makes organic and agricultural chemicals in Iowa significantly specialized. In addition to the regional specialization, Iowa's employment level represents an increasing concentration. The subsector's fast-paced growth is a major reason for the state's growing specialization.

Emerging Potential

The drugs and pharmaceuticals subsector is the second fastest-growing bioscience subsector and outpaced growth of this industry at the national level. The growth that Iowa experienced in drugs and pharmaceuticals, bringing employment levels above 2,500 across 44 establishments, surpassed the U.S. growth rate of 11.3 percent. The ability of drugs and pharmaceuticals to remain ahead of national employment growth rates has contributed to a rising employment concentration.

The medical equipment and supplies subsector experienced the second fastest employment growth rate in Iowa relative to the United States. Though growth was only half as much as the drugs and pharmaceuticals subsector, medical equipment and supplies was second only to organic and agricultural chemicals in terms of relative growth compared with the nation. Iowa's employment base in the medical equipment and supplies subsector grew by 6.1 percent. Across the nation, subsector employment in medical equipment and supplies decreased by 0.6 percent. Despite the encouraging growth trend over the past four years, the medical equipment and supplies subsector in Iowa remains small. In 2002, the subsector employed 1,847.

The hospitals and laboratories subsector is Iowa's largest bioscience subsector and is growing. The Iowa hospitals and laboratories subsector employed 41,882 in 2002. Although not often considered at the forefront in bioscience research or production, hospitals and laboratories are important contributors. In particular, health centers perform clinical trials and collaborate with companies on research and development.

Transitional

The agricultural machinery and equipment subsector is the most specialized bioscience subsector in Iowa. In 2002, the subsector employed more than 10,000 workers across the state. This level of employment is far above the national level. The agricultural machinery and equipment subsector in Iowa possesses a location quotient of 11.83. This concentration level represents an employment base in the state that is more than 10 times the national level.

The agricultural processing subsector is the largest agriculture-related bioscience subsector in terms of employment size and the second most regionally specialized subsector in Iowa's bioscience industry. In 2002, the agricultural processing subsector employed 19,458 across 976 establishments within the state. The subsector's size is demonstrated by examining the average establishment size. The typical

agricultural processing establishment in Iowa employs 22 individuals. Nationally, the average establishment employs 16 individuals.

In Iowa, the agricultural processing subsector is more concentrated and is composed of larger firms. The state's employment concentration in the agricultural processing subsector is more than seven times greater than the national average. The location quotient of 7.34 clearly represents a strong regional specialization.

The agricultural services subsector also is regionally specialized. The agricultural services subsector is the smallest of all the bioscience subsectors, employing 1,187 in 2002. Although small in size, the subsector is significantly concentrated and is considered to be regionally specialized in Iowa. The subsector is more than twice as concentrated in Iowa as in the nation.

Economic Analysis Summary

Key conclusions from the economic analysis of Iowa's current economic base include the following:

1. The bioscience industry is a significant contributor to the Iowa economy. In 2002, bioscience employment accounted for 7.0 percent of total employment in Iowa, exceeding the national average of 5.6 percent of total private-sector employment. The strength that Iowa demonstrates in this technologically advancing industry suggests that this sector of the economy is an asset for the state upon which to build.

Another way to observe the impact of the bioscience industry on the state economy is by examining the gross state product (GSP) of Iowa. The health services, food and kindred products, and chemicals and allied product subsectors making up the bioscience sector account for large shares of Iowa's GSP. In fact, compared with the United States, each subsector in Iowa has a larger share of the GSP (Table 2).

Table 2: Bioscience Share of Gross State Product, 2001

2001 Gross State Product	Iowa		United States	
Industry	(millions of current dollars)	Percent Share of Total GSP	(millions of current dollars)	Percent Share of Total GSP
Total Gross State Product	90,942	100.00%	10,137,190	100.00%
Farms	2,831	3.11%	80,596	0.80%
Ag. services, forestry, and fishing	623	0.69%	60,054	0.59%
Food and kindred products	3,788	4.17%	123,683	1.22%
Chemicals and allied products	2,880	3.17%	163,456	1.61%
Health services	5,653	6.22%	589,788	5.82%

Source: U.S. Bureau of Economic Analysis, 2001 Gross State Product by Industry Category, Released April 2003

2. Iowa's bioscience industry is diverse, with subsectors that are growing rapidly. Iowa has a significant concentration in the organic and agricultural chemicals subsector that is growing rapidly. The drugs and pharmaceuticals and medical equipment and supplies subsectors also offer potential as they are growing rapidly. Finally, Iowa has a mature base in the biosciences represented by the number of subsectors in which Iowa is considered to be specialized, including agricultural machinery and equipment, agricultural processing, and agricultural services.

3. The bioscience industry is a tremendous source of well-paying jobs. Compared with other major Iowa industries, the bioscience industry is one of the highest paying in the state. The average wage of a

bioscience worker in 2002 exceeded the statewide average annual wage by more than $12,700 and surpassed wages in such sectors as manufacturing; information; construction; and finance, insurance, and real estate (FIRE) (Table 3). Because the bioscience industry is diversified, comprises a substantial share of state economic activity, and is a source of high-paying jobs, it is reasonable to support initiatives that focus on it.

Table 3: Average Iowa Annual Wages per Employee, 2002*

Organic and Ag Chemicals	**$52,760**
Ag Machinery and Equipment	**$51,672**
Ag Processing	**$46,318**
FIRE	$40,471
Biosciences	**$39,253**
Wholesale Trade	$38,300
Manufacturing	$38,230
U.S. Total Private Sector	$36,517
Transportation and Utilities	$35,708
Information	$34,830
Construction	$34,777
Iowa Total Private Sector	**$29,158**
Professional Business Services	$28,630
Ag/Natural Resources and Mining	$25,364

*** Wages are based on 2002 ES-202 data from the Bureau of Labor Statistics (BLS) and the Iowa Workforce Development's Employment Statistics Bureau. 2002 Information for the U.S. was retrieved from the BLS and is considered preliminary according to the Department of Labor.**

Conclusions

The economic analysis of the Iowa bioscience economy indicates that the industry is dominated by the agriculture-related subsectors. In particular, three subsectors are well positioned to be the foundation of a comprehensive economic development strategy (Table 4). The organic and agricultural chemicals subsection is a sizable, growing regional specialization that is extremely well-positioned to benefit from increases in ethanol production (an organic chemical). Agricultural processing is the largest of the agriculturally based bioscience subsectors and represents a solid base that is significantly more specialized in Iowa than in the nation and possesses an average annual wage per employee that is higher than the national average. Similarly, agricultural machinery and equipment exhibits a solid employment base and high average annual wage.

Table 4: Key Iowa Bioscience Subsectors

Key Iowa Bioscience Subsectors

Subsector	2002 Employment	Location Quotient
Organic & Agricultural Chemicals	4,416	3.51
Agricultural Processing	19,458	7.34
Agricultural Machinery & Equipment	10,115	11.83

Source: Battelle calculations based on ES-202 data from the U.S. Department of Labor's Bureau of Labor Statistics and Iowa Workforce Development's Employment Statistics Bureau.

The better-than-average employment growth rate exhibited between 2000 and 2002 suggests that the bioscience industry represents an economic development opportunity for Iowa. This opportunity can have even more impact if industrial and academic initiatives are linked and focused around similar priorities. To create a more durable and vibrant bioscience industry, the State of Iowa must target initiatives to support existing strengths and encourage and stimulate emerging subsectors. While Iowa must tailor initiatives to target those niches with the greatest promise of economic growth, the state must not lose sight of the inherent diversity of bioscience activity. The challenge that state leaders face is the need to balance initiatives between solidifying core areas within the biosciences and promoting new innovative industrial technologies that promise continual economic growth.

Battelle also conducted a recent study for BIO, the national biotechnology trade association, which compared Iowa with the other 49 states using a more narrow definition of agriculture than that used in this report. Nevertheless, that report demonstrated Iowa's national leadership role in bioenergy, biofuels, and related biomass initiatives. Iowa is one of only six states in the nation that have both a large employment base and a significant specialization in agricultural feedstock and chemicals, which includes organic and agricultural chemicals and agricultural processing and is focused on industrial applications geared toward production agriculture, energy, industrial commodities, and specialty health products.[7]

IOWA'S BIOSCIENCE R&D BASE

Major university and nonprofit research institutions not only are the key to basic research discoveries that generate product leads for bioscience companies, but, more importantly, create an environment in which bioscience companies can flourish. Moreover, these institutions can be an asset for the bioscience industry in bridging the gap between basic and applied research.

Key trends in life science research, particularly focused on university research activity, are examined in the following paragraphs. In assessing Iowa's position in the biosciences, Battelle reviewed published statistics that allowed comparison of Iowa institutions to other leading bioscience institutions. Sources of information included

- External, national research funding sources, including National Science Foundation (NSF), U.S. Department of Agriculture (USDA), and National Institutes of Health (NIH) grant funding;
- Institute for Scientific Information (ISI) science publications citation index statistics;
- Proprietary Battelle Starlight™ analysis tools for mining research and patent abstract information to identify clusters of research expertise and focus.

Iowa's Position in Bioscience R&D

From the standpoint of academic funding for R&D, the State of Iowa is performing well for its size. With $439.8 million in research funds, Iowa ranks 24th in total university R&D funding (according to the NSF)—notably exceeding its population rank of 30th.

Within the academic R&D arena, the state is performing particularly well in the biosciences, with 66 percent of all academic research funds falling under this definition. This level of performance places Iowa 21st in the nation. Also, Iowa ranks well across the three major macro-categories of bioscience R&D (Table 5):

- 19th in medical sciences ($138 million)
- 20th in agricultural sciences ($50 million)
- 22nd in biological sciences ($84 million).

[7] Battelle Technology Partnership Practice and SSTI. *Laboratories of Innovation: State Bioscience Initiatives 2004*, www.bio.org, June 2004.

Table 5: Iowa Bioscience-Related Funding

R&D Funding at Iowa Universities (Rank of State of Iowa vs. Other States - For 7 Iowa Colleges & Universities)			
Field	**FY 2001**	**% U.S.**	**Rank**
TOTAL OF ALL ACADEMIC DISCIPLINES	**$ 439,810**	**1.3%**	**24**
LIFE SCIENCES TOTAL	**$ 290,912**	**1.5%**	**21**
Agricultural Sciences	$ 49,993	2.2%	20
Biological Sciences	$ 84,185	1.4%	22
Medical Sciences	$ 137,689	1.4%	19
Other Life Sciences	$ 19,045	2.5%	15
OTHER CRITICAL SCIENCES			
Chemical Engineering	$ 3,558	0.9%	32
Chemistry	$ 9,625	1.0%	30

Source: National Science Foundation, *Survey of Research and Development Expenditures at Universities and Colleges,* and Battelle calculations, FY 2001.

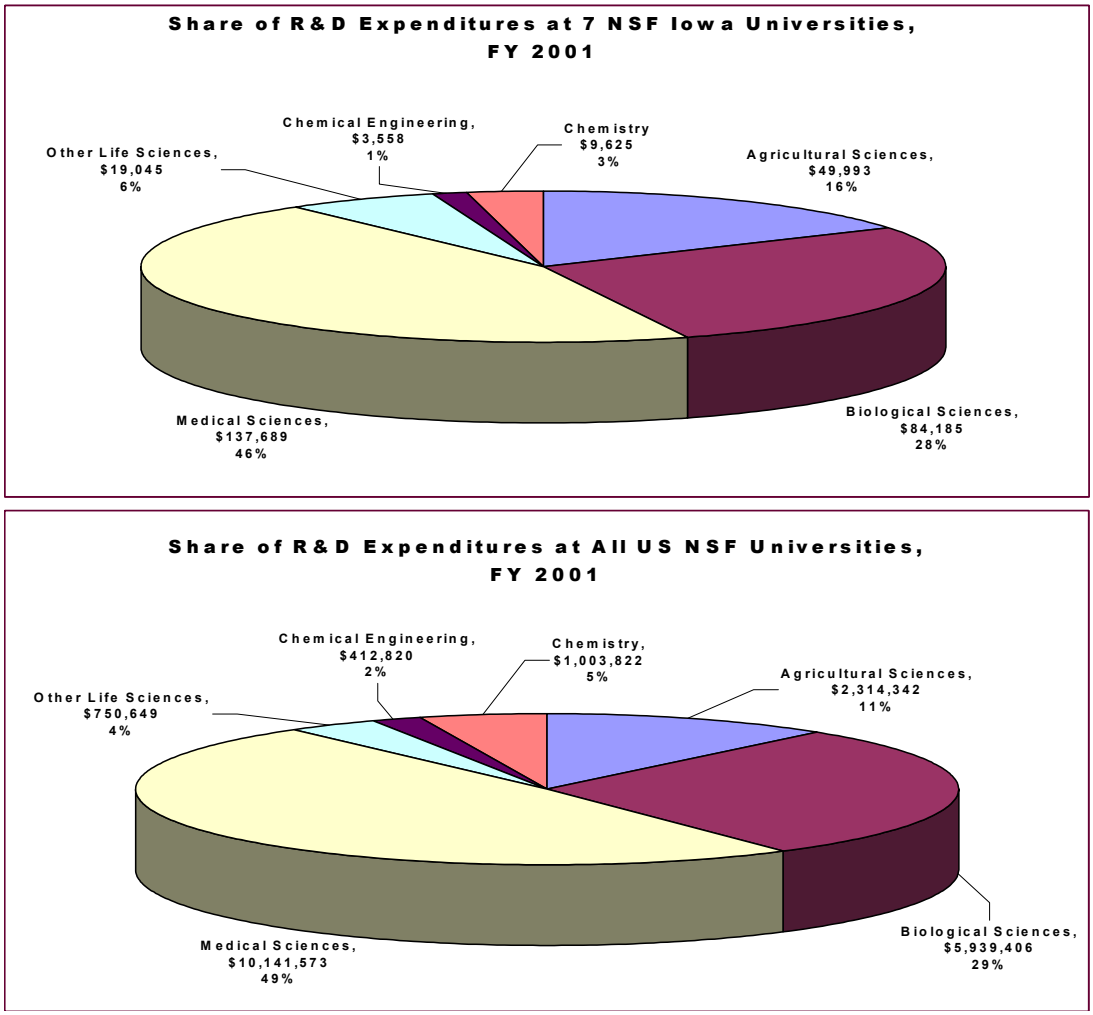
As the pie charts in Figure 4 illustrate, the percent of each type of bioscience and associated sciences R&D in Iowa is quite similar to that in the nation as a whole, except that Iowa has a significantly higher-than-average concentration in agricultural sciences (16 percent versus 11 percent nationally).

Finally, Iowa ranks 25th in total NIH awards, considered one of the "gold standards" of bioscience funding (Figure 5). Once again, this performance exceeds the state's population ranking.

Iowa's comparatively strong performance in bioscience R&D cannot, however, be taken for granted. The biosciences are a key target for growth in many states; and, in recent years, Iowa's total growth in bioscience funding has not kept pace with that of the nation—resulting in a slightly declining bioscience R&D market share of total academic R&D (Figure 6).

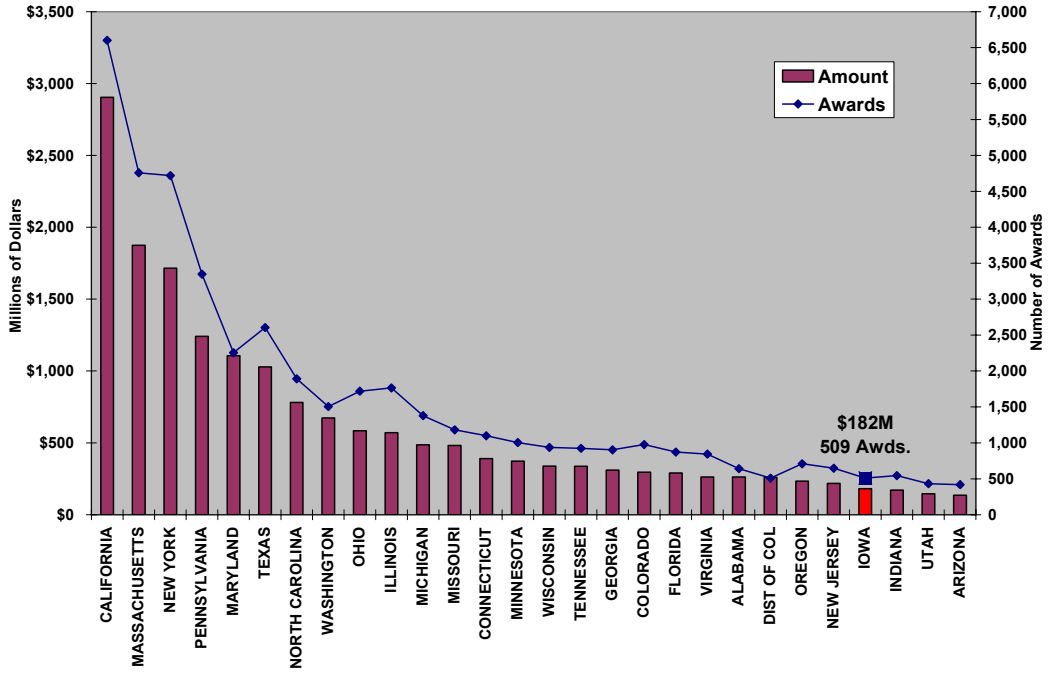
Key data relating to Iowa's recent performance in the biosciences are highlighted in Table 6 and further explain how Iowa has not kept pace with national bioscience research funding trends. The data show that Iowa has a greater concentration of total academic R&D in the biosciences than the national average and also that bioscience academic R&D spending per capita is considerably above the U.S. average. ***This comparative concentration in the biosciences is declining somewhat as Iowa's growth in bioscience R&D funding has not kept pace with the growth rate of U.S. bioscience research.*** To put it another way, if Iowa's bioscience R&D increase from 1997 to 2001 had kept pace with the overall U.S. growth rate, Iowa would have received approximately $8 million more in bioscience R&D funding in FY 2001.

Figure 4: Share of Bioscience-Related R&D for Iowa and the United States



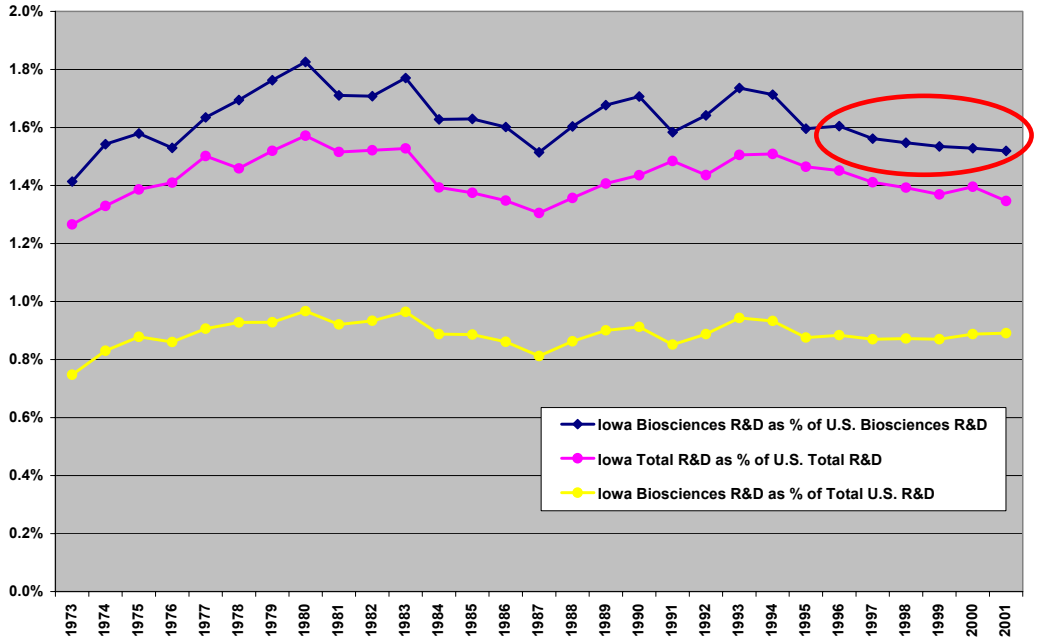
Source: National Science Foundation, *Survey of Research and Development Expenditures at Universities and Colleges,* and Battelle calculations, FY 2001.

Figure 5: Total NIH Funding and Number of Awards, FY 2002



Source: National Science Foundation, *Survey of Research and Development Expenditures at Universities and Colleges,* and Battelle calculations, FY 2001.

Figure 6: Academic R&D in Iowa as a Percentage of U.S. Academic R&D



Source: National Science Foundation, Survey of Research and Development Expenditures at Universities and Colleges, and Battelle calculations, FY 2001.

Table 6: Recent Bioscience Performance in Iowa and the United States

Metric	Iowa	United States
Total Academic R&D, FY 2001	$439,810,000	$32,652,261,000
Total Bioscience R&D, FY 2001	$290,912,000	$19,145,970,000
Bioscience as a % of All Academic R&D	66.1%	58.6%
Annual Academic Bioscience R&D Per Capita, FY 2001	$99.22	$67.10
% Increase in Academic Bioscience R&D, FY '97–01	37.7%	41.5%

Source: National Science Foundation, Survey of Research and Development Expenditures at Universities and Colleges, and Battelle calculations, FY 2001.

Iowa's Bioscience R&D Strengths

The previous section highlighted basic trends in academic bioscience R&D activity within Iowa. In this section, the analysis is extended to examine the specific areas of bioscience and bioscience-related activities that are receiving extramural funding. It is important to note that, as mentioned earlier, the biosciences are broad and no state has core strengths in every aspect of them. In Iowa, quantitative data on funding by discipline, publications citations, and numbers of grants serves to highlight some of the fields in which Iowa has a specialization.

NIH data show that the University of Iowa College of Medicine performs particularly well in funding for

- Orthopedics (where it ranks third in the nation);
- Public health and preventative medicine (fifth);
- Otolaryngology—ear, nose and throat (fifth);
- Pediatrics (eighth);
- Anesthesiology (10th); and
- Biostatistics and related math sciences (11th).

Iowa State University also received NIH awards, but performs particularly well in accessing NSF and USDA awards. Iowa State performs well in multiple disciplines, including biological infrastructure, environmental biology, integrative biology and neuroscience, and molecular and cellular biosciences. Iowa State's USDA funding highlights its work in veterinary medicine and animal sciences.

The ISI publishes statistics on the publications frequency and impact of academic institutions. Within Iowa, several university disciplines are strong performers on ISI metrics. The data show that Iowa is particularly powerful in

- Clinical immunology and infectious diseases;
- Agriculture and agronomy;
- Anesthesia and intensive care;
- Otolaryngology;
- Entomology and pest control; and
- Ophthalmology.

Other disciplines that are strong in terms of citations include agricultural chemistry, dentistry, oral surgery and medicine, microbiology, veterinary medicine, and animal health.

Both the grants funding and ISI data serve to highlight several factors:

- There is significant institutional depth in a broad range of bioscience, biomedical, and related disciplines. Both Iowa State University and the University of Iowa contribute to this depth.
- Iowa has strengths in the three primary components of bioscience— plant sciences/agricultural science, veterinary medicine/animal health, and human medicine.
- The University of Iowa is particularly strong and productive in clinical immunology and infectious diseases, immunology, otolaryngology, ophthalmology, anesthesia and intensive care, and clinical psychology and psychiatry.
- Iowa State University has demonstrable impact in agriculture/agronomy and entomology and pest control. The University also has a strong concentration in agricultural chemistry, animal and plant sciences, veterinary medicine and animal health, and food sciences and nutrition.
- Both the University of Iowa and Iowa State University have strengths in environment/ecology research.

A quantitative analysis was completed, using Battelle's own proprietary Starlight™ cluster analysis software system. Starlight™ uses pattern recognition algorithms on text data (grant abstracts) to find areas in which a critical mass of research is occurring. This analysis identified six "meta clusters" of research in Iowa comprising

- Cell and molecular studies
- Crop and soil analysis
- Disease and infection studies (both human and animal/agricultural)
- Genetics
- Neural studies
- Vascular analytics.

Iowa's performance in the cell/molecular studies and genetics fields (with 510 grants and 259 grants, respectively) is particularly noteworthy given the importance of these disciplines to modern bioscience progress. Strengths in these disciplines are provided by both the University of Iowa and Iowa State University.

Taking all of the quantitative data into account, Tables 7 and 8 list Iowa's broadly based and human medicine/health core focus areas, respectively.

Table 7: Iowa's Broadly Based Core Focus Areas Suggested by Quantitative Data

Core Focus Areas	Federal Research Grants			Publication & Citation Strength (ISI Data)	Starlight Cluster Analysis		Academic Reputation (*U.S. News & World Report* Rankings)
	NIH	NSF	USDA		Grants	Patents	
Plant Breeding and Genetics		✓	✓		✓	✓	
Biotechnology and Applied Microbiology	✓	✓	✓	✓	✓	✓	
Immunology and Infectious Disease	✓		✓	✓	✓		
Agricultural Equipment Engineering			✓			✓	✓
Food Safety and Nutrition	✓		✓	✓			
Materials Science						✓	
Agricultural Chemicals			✓	✓			
Entomology and Pest Control		✓	✓	✓			
Veterinary Medicine and Animal Health		✓	✓	✓			✓

Table 8: Iowa's Human Medicine/Health Core Focus Areas Suggested by Quantitative Data

Core Focus Areas	Federal Research Grants			Publication & Citation Strength (ISI Data)	Starlight Cluster Analysis	Academic Reputation (*U.S. News & World Report* Rankings)	Best Hospitals (*U.S. News & World Report* 2003 Rankings)
	NIH	NSF	USDA		Grants		
Anesthesiology	✓			✓		✓	
Audiology	✓					✓	
Biostatistics	✓						
Cardiovascular	✓				✓		
Neurosciences, Neurology & Neurosurgery	✓	✓			✓		✓
Nursing						✓	
Oncology				✓	✓		
Ophthalmology				✓			✓
Orthopedics	✓						✓
Otolaryngology	✓			✓			✓
Pediatrics	✓						
Public Health & Preventative Medicine	✓					✓	
Radiology & Radiation Diagnostics	✓						

Conclusions

Iowa is strong and diversified in its bioscience R&D base and has a small but growing commercial base in certain related disciplines. The R&D basics are in place across agricultural bioscience, animal science, and human/medical bioscience, and the leading universities are already working on collaborations to help advance their bioscience work.

The next section examines Iowa's specific bioscience core competencies based on the convergence of its industrial and academic research bases, both established and emerging, in order to identify specific areas of opportunity for bioscience development in Iowa. For more in-depth detail on both the methodology for and analyses of the quantitative and qualitative data collected on Iowa's bioscience R&D base and core competencies, please see the Phase I report, *The State of Iowa: Biosciences Path for Development: Economic and Core Competency Analyses.*

Opportunities for Bioscience Development in Iowa

Understanding Iowa's research core competencies requires identifying the key research strengths and drivers for bioscience development in the state. But, realizing economic impact from these strengths requires identifying and developing key technology platforms around which this research can be commercialized in products, processes, and market-driven niches. Identifying core competencies also helps focus on the state's specific possibilities for becoming a bioscience growth center around major niches and opportunities. Of particular importance is the ability of a state to have specific areas for near-term development (within the next 2 to 5 years) that takes advantage of core research strengths that will contribute to economic growth. It is these near-term development areas that can launch a state on its way to becoming a thriving center for the biosciences and provide the foundation for longer-term investments needed to establish broader core competencies for growth.

Because research and industry development in the biosciences are closely linked, with industry relying on research to generate new bioscience products, it is helpful to focus on areas of primary research for near-term development. But, research alone is insufficient to ensure bioscience development. The most likely areas for bioscience development can be found where research intersects with a state's industry base, competitive advantages, and market opportunities.

The criteria for selecting opportunities for technology development include areas in which there are

- Existing research focus strengths;
- Bases of commercial activity emerging or established within the state, or a genuine opportunity to create a base in the near future;
- Distinct opportunities to leverage the state's comparative advantages to create competitive marketplace advantages;
- Significant product market potential; and
- Links to, or reinforcements of, other bioscience strengths and core research competencies, thereby helping to enhance other fields as it expands.

IOWA'S BIOSCIENCE CORE COMPETENCIES

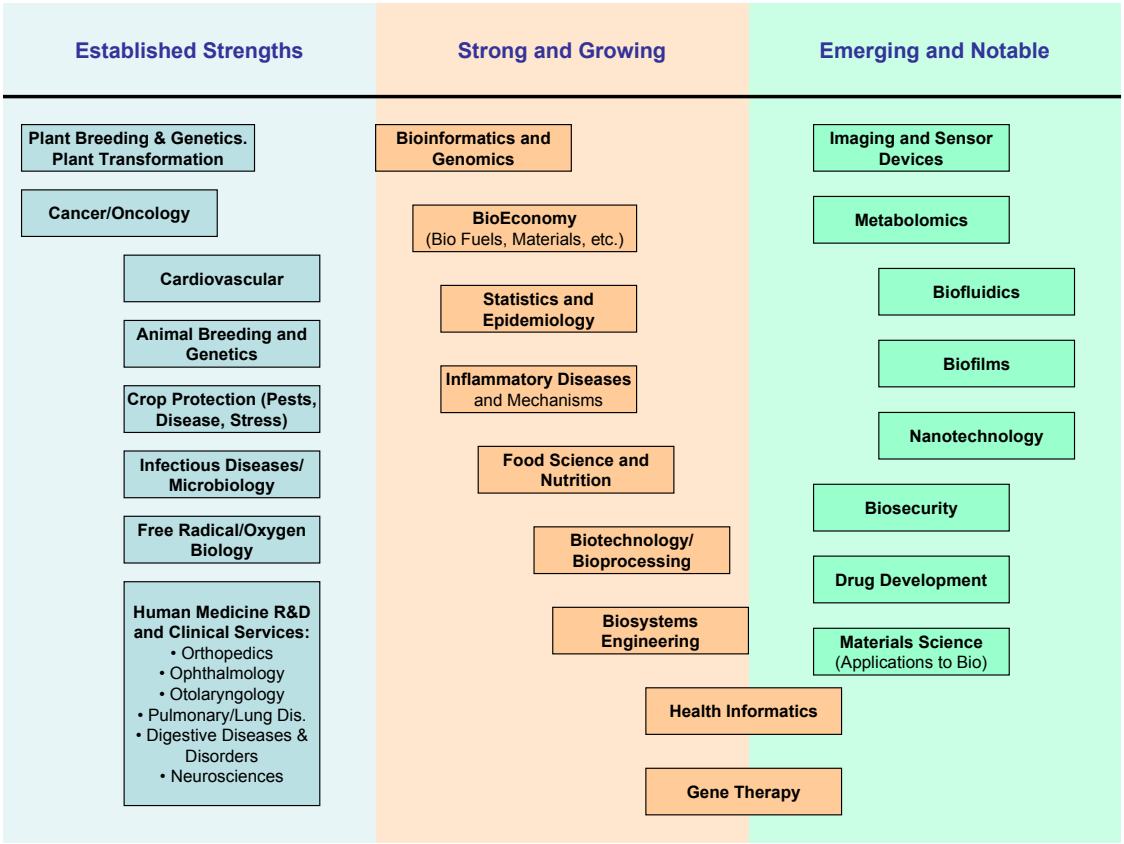
The previous analysis of quantitative data sets a context for understanding where Iowa's core competencies in bioscience research are focused. To further investigate these fields and understand the core bioscience focus areas in Iowa, extensive qualitative interviews were conducted with university administrators, faculty, scientists, clinicians, industry executives, and development agencies in the state.

The interviews, for the most part, confirmed the areas of specialization in Iowa identified in the quantitative analysis. They also, however, highlighted several new and emerging areas of R&D focus and some key theme areas that were not readily apparent within the quantitative datasets. One challenge in using quantitative data is the rapid rate of change in scientific enterprise. Peer review systems—whether used for federal grant awards, citation analysis, or in reputation rankings—tend to lag emerging new fields of inquiry, missing younger and new scientific talent. One objective of the qualitative interviews was to capture emerging areas, faculty, and fields of inquiry at each of the three universities.

After performing the qualitative interviews, conclusions were formed that placed each of the identified strength areas into one of three categories:

- **Established Strengths**—Comprising the "powerhouse" disciplines in which Iowa has a clear leadership position on which to build.
- **Strong and Growing**—Comprising fields that are fast growing in general (such as genetics and bioinformatics in which the state is particularly strong but need further development) but less fully established than the preceding category.
- **Emerging and Notable**—Comprising smaller or embryonic programs that still show significant potential for bioscience development in Iowa.

Figure 7: Iowa's Strength Areas Based on Qualitative Assessment

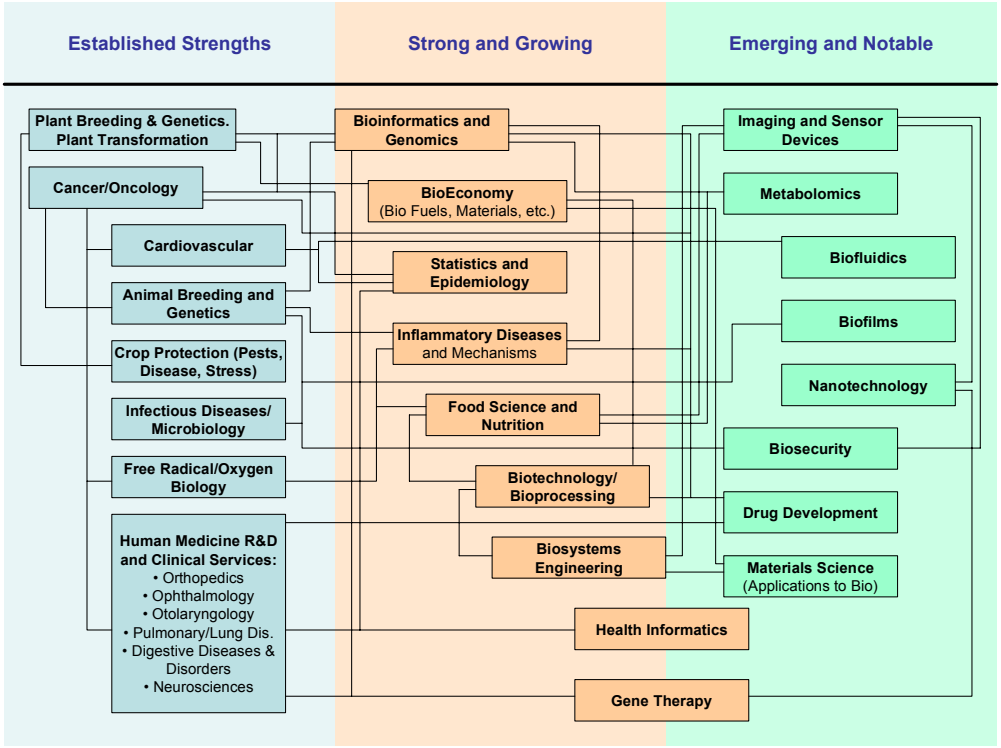


Bioinformatics and genomics are strongly positioned in Iowa at both the University of Iowa and Iowa State. However, genomics and post-genomic sciences are the basic pillar upon which much bioscience progress will be made. Other states are investing heavily in initiatives to enhance their genomics, proteomics, metabolomics, and bioinformatics infrastructures and bolster their positions in these critically important fields. While this field is a key strength in the state and was classified as "strong and growing" in Iowa, it is an area of great competition and growth where momentum must be maintained.

In the modern biosciences, seldom does an area of focus stand on its own. Rather, the biosciences should be viewed as a system of interrelated disciplines and areas of study that support and assist one another.

For this reason, the NIH and similar organizations are focusing more grant-making attention on multidisciplinary institutes, centers, and research teams. Figure 8 illustrates some of the interrelationships and supporting links that exist among Iowa's bioscience strength areas. These and other links are explored in detail in the analyses that follow regarding technology platforms and opportunities.

Figure 8: Interrelationships Among Iowa's Interview-Identified Bioscience Strength Areas



The links between strength areas are critical to the emergence of bioscience core competencies in Iowa. As in any system, a change in one of the parameters (strength areas) is likely to affect the operation of others. For example, an enhanced center for the support of drug development with associated pilot facilities likely would increase the attention of various medical and veterinary disciplines on drug discovery activities. Equally, such an enhancement could spur biosystems engineering work on bio-processing activities for drugs or lead to an increased nanotechnology focus on drug delivery.

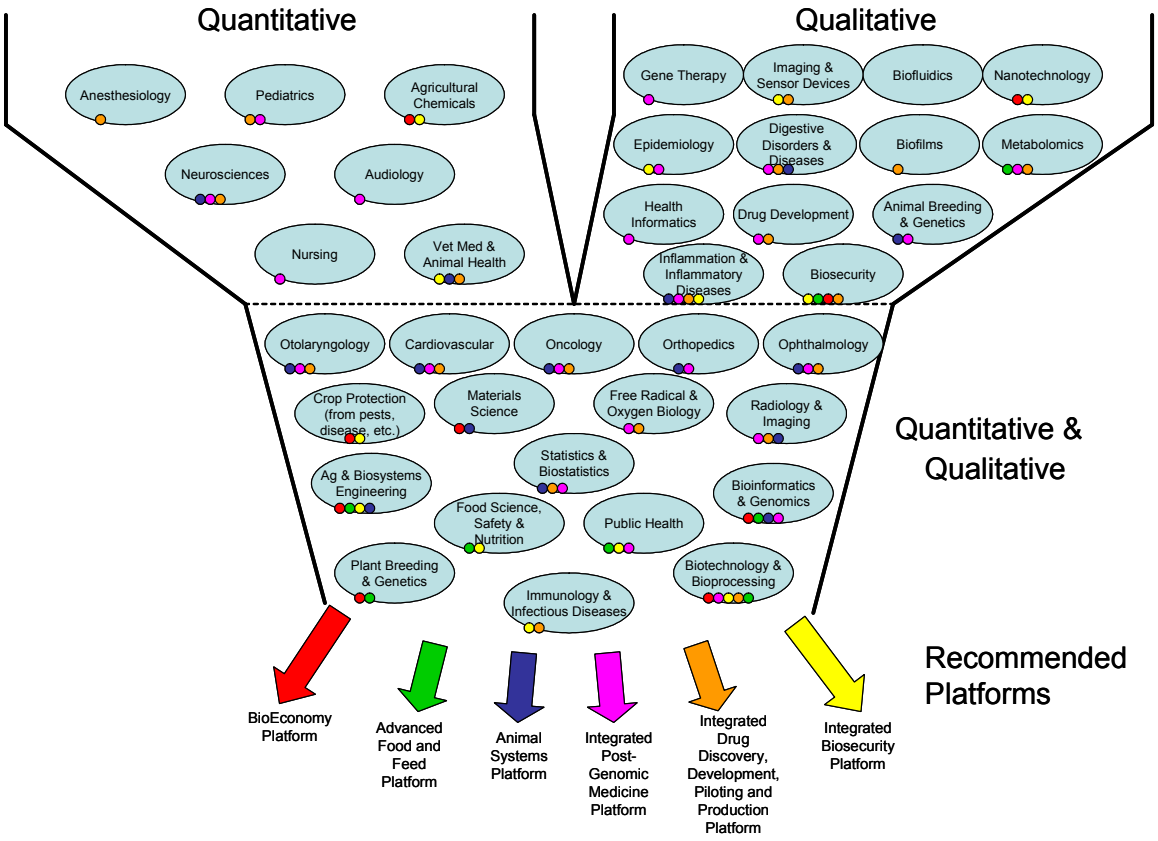
CORE PLATFORMS FOR IOWA BIOSCIENCE DEVELOPMENT

The quantitative and qualitative data served to identify core areas of strength and expertise in Iowa biosciences, represented in the figures above. Not all of these, however, can form the basis of platforms upon which economic development can be built. Rather, the project team's experience and expertise, in combination with market data, helped determine which core competencies, or combinations of core competencies, may form solid technology platforms for economic progress.

Battelle's quantitative and qualitative analyses reveal multiple core competency areas within academic R&D in Iowa—most notably centered on Iowa State University and the University of Iowa, with some supporting strengths at the University of Northern Iowa (notably in the BioEconomy and Integrated

Biosecurity platforms). These core competency areas are summarized in Figure 9, which shows the strengths identified by Battelle's quantitative and qualitative analyses, together with recommended technology platforms for resulting bioscience development.

Figure 9: Iowa's Validated Research Strengths Leading to Recommended Platforms



As Figure 9 illustrates, Battelle sees opportunity for Iowa to develop its bioscience economy upon multiple **short- or near-term** "platforms." These include the following:

- **BioEconomy Platform**—Using plant and animal biomass and waste streams to generate chemicals, energy, fuels, and materials for industrial and commercial applications.
- **Advanced Food and Feed 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.
- **Animal Systems Platform**— Using Iowa's bioscience and genomics expertise to establish a leadership position in the modeling of animal systems and in the development of technologies and applications for genes, genetic markers, transgenic animals, chimeric animals, and cloning.
- **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.

- **Integrated Drug Discovery, Development, Piloting, and Production Platform**—Leveraging Iowa's strengths in basic biomedical research, drug development, and Good Manufacturing Practice(s) (GMP) production into an integrated pipeline of new drugs and therapeutics.
- **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, and human health and safety.

These six areas represent broad platforms upon which a significant R&D base, business base, and bioscience economy may be built in Iowa in the near to short term. They each specifically draw upon Iowa's institutional expertise in multiple fields, because multidisciplinary research increasingly is gaining importance in driving funding, new study areas, technologies, discoveries, and commercializable innovations. In each case, the analysis shows that these platforms match well with large and rapidly growing projected domestic and international markets. In most cases, the markets are characterized in terms of having expanding multibillion-dollar existing and emerging potential. In addition to these broad platforms, biomedical imaging is a niche platform that is an opportunity for developing in the near term.

Each of the bioscience development platforms presents unique opportunities for bioscience-based economic advancement in Iowa. In the section that follows, some of the specific strengths for each platform are outlined.

BioEconomy Platform Strengths to Leverage

The BioEconomy Platform uses plant and animal biomass and waste streams to generate chemicals, energy, fuels, and materials for industrial and commercial applications. The rapid development of Iowa's leadership position in the BioEconomy will be built upon an existing base of strengths.

Key Industry Strengths	▪ A significant base of companies currently manufacturing fuels, chemicals, and materials from biorenewable resources ▪ A large-scale source of raw biomass feedstocks generated by Iowa's highly productive agricultural sector ▪ An infrastructure conducive to the movement of bulk materials and finished products ▪ A well-educated, productive workforce and workforce development system
Strengths of Lead R&D University: Iowa State University	▪ Plant Sciences Institute and its associated centers, including the Center for Bioinformatics, Center for Plant Genomics, Center for Plant Transformation, Center for Designer Crops, Center for Responses to Environmental Stresses, and the Center for Plant Breeding ▪ Agriculture and Home Economics Experiment Station and its associated centers/institutes including the Center for Crops Utilization Research (CCUR) and the Center for Integrated Animal Genomics (CIAG) ▪ Center for Catalysis ▪ Center for Sustainable Environmental Technologies ▪ Biomass Energy Conversion Facility ▪ Center for Industrial Research and Service (CIRAS) ▪ Individual departmental strengths ▪ Agricultural and manufacturing extension services ▪ Incubator and research park space and services
Supporting Strengths: University of Iowa	▪ Center for Biocatalysis and Bioprocessing ▪ Incubator and research park space and services
Supporting Strengths: University of Northern Iowa	▪ The Center for Ag-Based Industrial Lubricants ▪ Bio-based aggregates via UNI Metal Casting Center

Advanced Food and Feed Platform Strengths to Leverage

The Advanced Food and Feed Platform uses 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.

Key Industry Strengths	▪ A significant base of companies currently in the agricultural processing sector (however, few in the food processing sector) ▪ Highly productive soils and agricultural production sector ▪ An infrastructure conducive to the movement of bulk materials and finished products ▪ A well-educated, productive workforce and workforce development system
Strengths of Lead R&D University: Iowa State University	▪ Food Science and Human Nutrition Department ▪ NIH Funded Botanical Supplement Center ▪ Institute for Food Safety and Security ▪ Plant Sciences Institute and its associated centers, including the Center for Bioinformatics, Center for Plant Genomics, Center for Plant Transformation, Center for Designer Crops, Center for Responses to Environmental Stresses, and the Center for Plant Breeding ▪ Agriculture and Home Economics Experiment Station and its associated centers/institutes including the Center for Crops Utilization Research (CCUR), Center for Integrated Animal Genomics (CIAG), the NASA Food Technology Commercial Space Center, and the ISU Meat Lab ▪ Center for Designing Foods to Improve Nutrition ▪ Individual departmental strengths ▪ Agricultural and manufacturing extension activities ▪ Incubator and research park space and services
Supporting Strengths: University of Iowa	▪ Collaborator with ISU on botanical supplement investigations ▪ Human health impacts of diet and nutrition ▪ Free radical/oxidative expertise

Animal Systems Platform Strengths to Leverage

The Animal Systems Platform uses 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.

Key Industry Strengths	▪ A base of companies currently producing biologics products from animal pathways (e.g., TransOva, Proliant) and in animal health (e.g., Fort Dodge) ▪ Efficient food animal production sector ▪ A well-educated, productive workforce and workforce development system
Strengths of Lead R&D University: Iowa State University	▪ Agriculture and Home Economics Experiment Station and its associated centers/institutes including the Center for Integrated Animal Genomics (CIAG), the NASA Food Technology Commercial Space Center, and the ISU Meat Lab ▪ Animal Gene Transfer Facility ▪ ISU Extension's Beef and Pork Centers ▪ Plant Sciences Institute resources in bioinformatics and other related areas) ▪ Individual departmental strengths especially in Animal Sciences Department and the College of Veterinary Medicine ▪ Agricultural and manufacturing extension services ▪ Incubator and research park space and services

Supporting Strengths: University of Iowa	▪ Transgenic Animal Core Facilities and Vector Core Facilities. Able to work on animal models of disease and assessing reversibility with gene transfer.

Integrated Post-Genomic Medicine Platform Strengths to Leverage

The Integrated Post-Genomic Medicine Platform uses 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.

Key Industry Strengths	▪ A small base of companies in the drugs and biologics sector ▪ A stable and participative population for clinical trials ▪ A well-educated, productive workforce and workforce development system
Strengths of Lead R&D University: University of Iowa	▪ Bioinformatics Center and deep associated expertise in genetics and genetic analysis ▪ Epidemiology ▪ Transgenic Animal Core Facilities ▪ Tissue banks in certain subspecialties ▪ Large and stable clinical population ▪ GMP drug and biologic production facilities
Supporting Strengths: Iowa State University	▪ Genetics and bioinformatics ▪ Statistics

Integrated Drug Discovery, Development, Piloting, and Production Platform Strengths to Leverage

The Integrated Drug Discovery, Development, Piloting, and Production Platform leverages Iowa's strengths in basic biomedical research, drug development, and GMP production into an integrated pipeline of new drugs and therapeutics.

Key Industry Strengths	▪ A small base of companies in the drugs and biologics sector ▪ A stable and participative population for clinical trials ▪ A well-educated, productive workforce and workforce development system
Strengths of Lead R&D University: University of Iowa	▪ GMP production facilities already registered with the Food and Drug Administration (FDA) and working in partnership with pharmaceutical and biotechnology industries (Pharmaceutical Services) ▪ Center for Advanced Drug Development, providing services to internal research groups and to external industry ▪ Major research programs in pharmacology , pharmaceutics, medicinal chemistry, biochemistry, immunology, epidemiology, chemical and biomedical engineering ▪ Biologics capabilities at the Center for Biocatalysis and Bioprocessing ▪ Comprehensive Cancer Center ▪ Clinical Trials Office ▪ College of Public Health
Supporting Strengths: Iowa State University	▪ Veterinary medicine drugs and biologics ▪ Animal models and systems, and clinical trials ▪ Animal toxicology ▪ Chemistry

Integrated Biosecurity Platform Strengths to Leverage

The Integrated Biosecurity Platform deploys 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, and human health and safety.

Key Industry Strengths	▪ A small base of companies in the drugs and biologics sector, including vaccine development ▪ Broad relevant industry base in agricultural production, agricultural chemicals, processing and transportation ▪ A well-educated, productive workforce and workforce development system

Strengths of Lead R&D University: University of Iowa	Note: It is anticipated that in the initial years of development the lead institution will be the University of Iowa. This is based on an initial human approach to biosecurity based on the existing Biodefense Planning Grant and the focus on respiratory infectious diseases. As biosecurity becomes a larger focus area in Iowa, Iowa State University will become increasingly engaged in a co-leadership position to provide integration of human health with animal health, agrosecurity, and environmental biosecurity.
	
	▪ Epidemiology
	▪ Infectious diseases
	▪ Microbiology
	▪ State Hygienic Lab with plans for significant expansion including BSL3 facilities for handling of biological and chemical materials
	▪ Significant recent success in securing NIH funding for
	  ○ Biodefense Planning Grant
	  ○ Respiratory Pathogens Research Contract
	  ○ Related program project grants
	▪ College of Public Health
	▪ College of Pharmacy
	▪ GMP drug and biologic production facilities

Supporting Strengths: Iowa State University	▪ Institute for Food Safety and Security ▪ Agriculture and Home Economics Experiment Station and its associated centers/institutes including the Food Safety Consortium and the Biosafety Initiative for Genetically Modified Products ▪ Center for Food Security and Public Health ▪ Department of Homeland Security groups on animal diseases and on post-harvest food security ▪ College of Veterinary Medicine ▪ Animal infectious diseases and pathology ▪ Plant diseases/plant pathology ▪ Analytical chemistry ▪ Environmental systems engineering, monitoring, sensors and controls ▪ Linear Accelerator Facility Note: Iowa is also home to the USDA Animal Health Research Laboratory. Ground was broken in early 2004 on a $460 million renovation project for the center in Ames.

Biomedical Imaging Niche Platform

The University of Iowa has had significant recent success in securing funding and strong industry relationships in biomedical imaging, with a specific focus on advanced lung imaging systems and software. In March of 2004, the Iowa Comprehensive Lung Imaging Center (I-Clic) opened to leverage

distinct strengths in quantitative imaging techniques applied to normal lung states and lung disease pathology. I-Clic will provide researchers with access to a dedicated imaging center equipped with the latest state-of-the art imaging equipment. The research team also will work closely with leading imaging equipment manufacturers in regards to future directions in imaging technologies.

The imaging effort at the University of Iowa is combining the College of Engineering Imaging Group (CEIG) with the College of Medicine I-Clic, with the intent to create the Iowa Biomedical Imaging Institute. This entity will cover image acquisition, new device development, very advanced image processing, image segmentation, image matching, image storage and retrieval, image display, and image analysis. It is important to note from an economic development perspective that this group has strong ties to major industries (Siemens, Olympus, Stereotaxis, plus new drug discovery trials, etc.), very strong NIH support, strong input into public policy nationally in relation to imaging, and very strong FDA interactions. Business spin-offs are already occurring, with two companies (Vida Technologies and Endographics) that together have approximately $2 million in federal Small Business Innovation Research (SBIR) funding. There are plans to merge both companies into a single entity. The imaging effort is continuing to develop, with new faculty recruits. In addition, the ISU linear accelerator facility might be leveraged to further these scientific pursuits.

Given the importance of advanced biomedical imaging as a provider of new insights that lead to new biomedical discoveries, and the potential to work on imaging devices, algorithms, and software business opportunities, Battelle sees this as a short-term niche for development in Iowa.

Longer-Term Core Competency Opportunities

In addition to the broad technology platforms, several areas of emerging, longer-term opportunity represent the potential for additional sector development. These areas consist of relatively compact groups of people working in leading-edge fields, new formative centers just recently pulled together, or established areas of expertise in which further investment in infrastructure and/or personnel are required to sustain or accelerate development momentum.

These four **longer-term** opportunity areas are as follows:

- **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. **An immediate opportunity exists in the area of Biomedical Imaging, with initial focus on lung imaging.**
- **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.

It should be noted that the list of near- or short-term competencies on which Iowa should focus will need to be nurtured and developed over the long-term as well. A number of these near-term competencies are ready to be initiated and involve ISU as a key leader. In addition, other cross-cutting, enabling

technologies will affect the above long-term list, and investments will need to be considered. One example of these technologies is the emerging bioinformatics capabilities at ISU.

SUMMARY

This assessment of Iowa's position in the biosciences highlights a state that has significant promise to be among the nation's bioscience leaders in selective fields. Iowa institutions have substantial strengths in the "three legs of the bioscience stool"—human, animal, and plant biosciences. In particular, the bioscience operations of both Iowa State University and the University of Iowa show fundamental bioscience technology platform strengths that can be further enhanced by increased collaborations between the institutions and with industry.[8]

[8] Platforms are not intended to supplant or replace the existing structure of Iowa State University in its agbioscience work. Battelle notes that Iowa State University has established a well-structured suite of centers under the umbrella of the Plant Sciences Institute and other formal Presidential initiatives, and recognition of this is shown in its analysis and recommendations in the Phase I report, *The State of Iowa Biosciences Path for Development: Economic and Core Competency Analyses.* It is highly important to Iowa's future in the BioEconomy that the ISU Plant Sciences Institute and its related centers continue to be funded and supported.

Iowa's Competitive Position in the Biosciences: Building a Bioscience-Driven Economy

KEY SUCCESS FACTORS

Boston, San Diego, the San Francisco Bay Area, the Research Triangle Park region, and the Baltimore/Washington region are generally regarded as among the nation's premier centers for research and testing and drugs and pharmaceuticals; Minneapolis, Memphis, and many others are leaders in medial devices. For each segment of the biosciences, geographical concentrations vary. For instance, Iowa stands out in agricultural biotechnology. The state has a large base of employment (more than 5 percent of total U.S. employment) in the agricultural feedstock and chemicals subsector, a subsector that focuses on practical implementation of biotechnologies using bioresources. In addition, the concentration of this industry in the state is 3.5 times that of the industry nationally. A recent separate report identifies only two states, South Carolina and Tennessee, as having a higher concentration than Iowa in the agricultural feedstock and chemicals subsector.[9]

Examining best practice states revealed a number of factors that have enabled these states to succeed in growing their bioscience bases. These success factors are highlighted below.

Engaged universities taking an active leadership role

Outstanding research universities are an absolute prerequisite for a state to become a serious contender in most areas of the biosciences, with the possible exception of medical devices (although this sector is also requiring more academic collaboration). However, research stature must be paired with the ability to engage industry, directly or indirectly, to convert research knowledge into economic activity through technology transfer and commercialization. To do so requires that one or more of a state's research universities become committed to engaging with and helping to build a local bioscience industry.

Key Success Factors

- Engaged universities taking an active leadership role
- Intensive networking across sectors and with industry
- Available capital covering all stages of the business cycle
- Discretionary federal or other R&D funding support
- Workforce and talent pool on which to build and sustain efforts
- Access to specialized facilities and equipment
- Stable and supportive business, tax, regulatory, and incentive policies
- Patience and a long-term perspective

Iowa Assessment. Iowa's regent universities demonstrate a growing willingness to engage in bioscience technology development, commercialization, and industry collaborations; but, a number of barriers (financial, operational, philosophical, and procedural) could prevent Iowa from having the type of university/industry relationships that drive other leading bioscience states. For instance, the universities are generally not taking equity positions in companies in place of higher licensing fees and royalty payments on intellectual property. Also, it is unclear whether the State of Iowa is constitutionally prohibited from taking an equity position in a company. Both Arizona and Utah have amendments on their Fall 2004 ballots for voter approval to enable universities to take equity in their intellectual property, and Oregon voters passed a similar measure in the Fall of 2003.

[9] Battelle Technology Partnership Practice and SSTI. *Laboratories of Innovation: State Bioscience Initiatives 2004*, www.bio.org, June 2004.

From a measurable quantitative standpoint, Iowa institutions have not excelled overall in terms of the impact that their research is having on economic development. Table 9 compares Iowa universities on various metrics of technology transfer performance (as compiled by the Association of University Technology Managers [AUTM]). These 3-year data compare the performance of the U of I and ISU with the nation as a whole and with three peer Midwest universities on selective measures developed by Battelle. This table identifies seven normalized performance metrics to measure technology transfer performance of research universities. As can be seen, Iowa's universities typically perform in the median of all universities and, in several instances, even outperform the top quartile of all universities. But, the metrics do suggest areas for improvement such as licensing of start-ups by all Iowa institutions and indicate variation among institutions on other measures. For example, in comparison to such leading Midwest universities as Wisconsin and Minnesota, Iowa's universities do not fare as well in such performance metrics as licensing income and start-ups; although, measurable variation exists among Iowa's research universities in terms of performance in these metrics.

Table 9: Iowa Technology Transfer Performance

FY 2000-2002 AUTM Licensing Data								
Metric	University of Iowa Research Foundation	Iowa State University	University of Northern Iowa	University of Illinois-Chicago and Urbana-Champaign	University of Wisconsin-Madison/WARF	University of Minnesota	*Top Quartile U.S. Universities*	*Median U.S. Universities*
Total Sponsored Research Expenditures	$794,976,617	$613,100,000	$6,779,779	$1,883,129,760	$1,820,604,000	$1,367,656,000	***$757,655,364***	***$365,472,746***
Invention Disclosures Received	237	329	3	616	918	683	***319***	***134***
Patent Applications Filed	232	225	4	401	548	460	***240***	***106***
U.S. Patents Issued	101	103	2	107	260	145	***77***	***35***
Licenses & Options Executed	94	713	5	211	401	233	***78***	***30***
Licenses & Options Yielding License Income	308	1181	8	482	609	684	***166***	***66***
Gross License Income Received	$17,496,246	$14,561,640	$149,572	$21,484,331	$79,226,941	$65,741,410	***$12,236,212***	***$2,871,721***
Start-Up Companies Formed	3	9	1	23	13	28	***10***	***4***
Disclosures per $10 M Sponsored R&D	8.94	16.14	13.77	9.83	15.16	15.03	***14.53***	***11.47***
Patents Issued per $10 M Sponsored R&D	3.84	5.06	8.97	1.70	4.31	3.25	***4.13***	***2.96***
Licenses Executed per $10 M Sponsored R&D	3.53	34.78	26.78	3.39	6.60	5.17	***4.13***	***2.74***
License Income per $10 M Sponsored R&D	$476,704	$572,437	$708,168	$191,435	$897,966	$1,086,003	***$384,794***	***$148,659***
Average Revenue per License	$171,284	$35,761	$48,351	$133,728	$390,255	$293,552	***$230,394***	***$117,105***
Start-Ups per $10 M Sponsored R&D	0.10	0.44	5.49	0.36	0.22	0.63	***0.59***	***0.30***
Start-Ups per License Executed	0.08	0.04	0.25	0.33	0.10	0.36	***0.56***	***0.33***

Source: Association of University Technology Managers

Intensive networking across sectors and with industry

The most successful clusters facilitate extensive and intensive networking not only between academe and industry, but also within industry as well. Momentum in bioscience development is built as bioscience company employees come together to share industry knowledge, brainstorm on potential scientific and technological advancements, discuss collaboration opportunities, mentor one another, and reach a shared agenda for advancing policies supportive of cluster growth. In a few leading regions, like Silicon Valley, this networking has occurred naturally, with formal facilitating organizations coming quite late in the game. However, in most states and regions, the organizations and networks designed to spur such catalytic interactions have been built from the ground up; otherwise, the desired degree, scale, and intensity of networking will not occur.

Iowa Assessment. In Iowa, some elements of the bioscience industry are networking through the Iowa Biotechnology Association and the BIOWA Development Association. **The Iowa Biotechnology Association** (IBA) was formed in 1994 to advance opportunities in Iowa for the improvement of the human environmental and economic well-being through the development and application of value-added technologies in the life sciences. Working cooperatively, the members hope to enhance the ability to commercialize new technologies in a timely manner and reduce the lead time for deployment. Activities of the association are designed to give companies doing business in Iowa an edge in delivering timely new products to consumers through the sharing of ideas regarding the transfer and development of technologies. IBA holds an annual statewide conference to promote issues and topics relevant to the life sciences and provide networking opportunities between industry, academia, and governmental organizations. **The BIOWA Development Association** is a nonprofit organization that supports and promotes the growth and development of Iowa's bioeconomy. It defines bioeconomy as an economy where the basic building blocks for industry and the raw materials for energy are derived from plant-based (renewable) sources. While both of these organizations are beginning to link Iowa's bioscience community, they have limited resources and are still in early stages of development. **Iowa State University** is also working to encourage networking through its Bioscience Mixer events. Despite these organizational efforts, Iowa has not yet achieved the critical mass of events, companies, and participants required to generate catalytic interactions.

Available capital covering all stages of the business cycle

Leading bioscience states share one characteristic—they are home to an indigenous venture capital community that is oriented toward early-stage financing and committed to the growth of local companies and investment opportunities. The presence of state-based capital and venture capital funds is critical to bioscience cluster development. It is equally critical that adequate funding resources be available to support each stage of commercialization and business development—from the very earliest proof-of concept/prototype and pre-seed funding, to seed and venture capital rounds of A, B, and C financing.

Iowa Assessment. Currently, Iowa's universities have extremely limited access to discretionary funds for the earliest stage of commercialization of their research innovations. This is limiting the movement of ideas from bench to early-stage venture formation. In other words, what is lacking is funding to build the "farm team," from which some members will graduate to the "major leagues" where Series A venture financing normally begins. While a limited number of venture funds exist in Iowa, only a handful at most are focused on the earliest stage, high-risk investments and even fewer on investment in bioscience business ventures. Significant gaps are apparent in access to funding at each stage in bioscience venture growth in Iowa.

The federal SBIR and Small Business Technology Transfer (STTR) Program is one source of early-stage funding. Typically, most bioscience funding comes through the NIH SBIR program. As Table 10 indicates, SBIR funds flowing to Iowa have increased significantly during the past 3 years. However, the state's portion of total NIH national funding allocation is very small (0.5 percent on average). This percentage has not increased between FY 2001 and FY 2003, indicating that Iowa is failing to tap this large and growing source of very early stage capital.

Table 10: Iowa's Level of NIH SBIR/STTR Awards

	Iowa NIH SBIR/STTR Awards	U.S. SBIR/STTR Awards	Iowa as a Percent of NIH SBIR/STTR Awards
FY 2001	$1,787,635	$419,448,220	0.4%
FY 2002	$2,814,781	$496,178,981	0.6%
FY 2003	$2,952,478	$541,494,021	0.5%
Total 2001–2003	$7,554,894	$1,457,121,222	0.5%
% Change 2001–2003	65.2%	29.1%	

While NIH SBIR funding is most closely related to the biosciences, SBIR programs funded through USDA and NSF also are relevant. While Iowa's percent of total U.S. SBIR/STTR awards is extremely small, there was a significant increase in SBIR funds awarded to companies in Iowa between FY 2001 and FY 2002 (Table 11).

Table 11: Iowa's Total Level of SBIR/STTR Awards

	Iowa Total SBIR/STTR Awards	U.S. Total SBIR/STTR Awards	Iowa as a Percent of U.S. SBIR/STTR Awards
FY 2001	S2,186,836	$1,221,487,825	0.18%
FY 2002	S5,914,136	$1,596,552,717	0.37%
Total 2001–2002	S8,100,972	$2,818,405,542	0.29%
% Change 2001–2002	170.4%	30.7%	

Finally, only $27 million of venture capital was invested in Iowa companies between 1998 and 2003. Of this amount, $14.5 million or slightly more than 50 percent was invested in Iowa bioscience companies. However, the majority of the investment in the biosciences in Iowa occurred in one year—1998 (Table 12).

Table 12: Iowa's Venture Capital Trends

Year	Total Venture Capital Investments	Bioscience VC Investments	Bio Share of Annual Total VC Funding
1998	$24,161,000	$11,841,000	49.0%
1999	$27,000,000	0	0.0%
2000	$17,496,000	$700,000	4.0%
2001	$4,350,000	0	0.0%
2002	$2,000,000	$2,000,000	100.0%
2003	$8,200,000	0	0.0%
Total	**$27,091,000**	**$14,541,000**	**53.6%**

Recent state initiatives to address capital gaps, including formation of a fund of funds, the Iowa Values Fund, and tax incentives for investors, should help to position Iowa to secure additional funding for these bioscience ventures in the future.

Discretionary federal or other R&D funding support

Building generic R&D assets into an effective attractor of technology investment requires leverage of substantial, ongoing, external, discretionary funding. Technology leaders like Silicon Valley, Boston, and San Diego were able to leverage decades of heavy defense contracting, while Baltimore and Washington leveraged growing congressional support of federal laboratories operated by the NIH, National Institute of Standards and Technology, and the FDA.

Iowa Assessment. Iowa has some federal institutions directly relevant to bioscience development, including the Ames Laboratory of the Department of Energy and the USDA's National Centers for Animal Health, also in Ames. The National Centers for Animal Health is particularly relevant because President Bush's proposed 2005 budget includes $178 million to complete a million-square-foot addition and renovation of the laboratories. The money would finish the project at a total cost of $460 million. Iowa thus has assets to leverage and build upon, but to date these resources have not proven to be key drivers of commercial bioscience and cluster development in the state.

As discussed previously, from the standpoint of academic funding for R&D, the State of Iowa is performing well for its size. With $439.8 million in research funds, Iowa ranks 24th in total university R&D funding (according to the NSF)—notably exceeding its population rank of 30th. Within the academic R&D arena, the state is performing particularly well in the biosciences, with 66 percent of all academic research funds falling under this definition. This level of performance places Iowa 21st in the nation.

Iowa's comparatively strong performance in bioscience R&D cannot, however, be taken for granted. The biosciences are a key target for growth in many states; and, in recent years, Iowa's total growth in bioscience funding has not kept pace with that of the nation—resulting in a slightly declining bioscience R&D market share of total academic R&D.

Workforce and talent pool on which to build and sustain efforts.

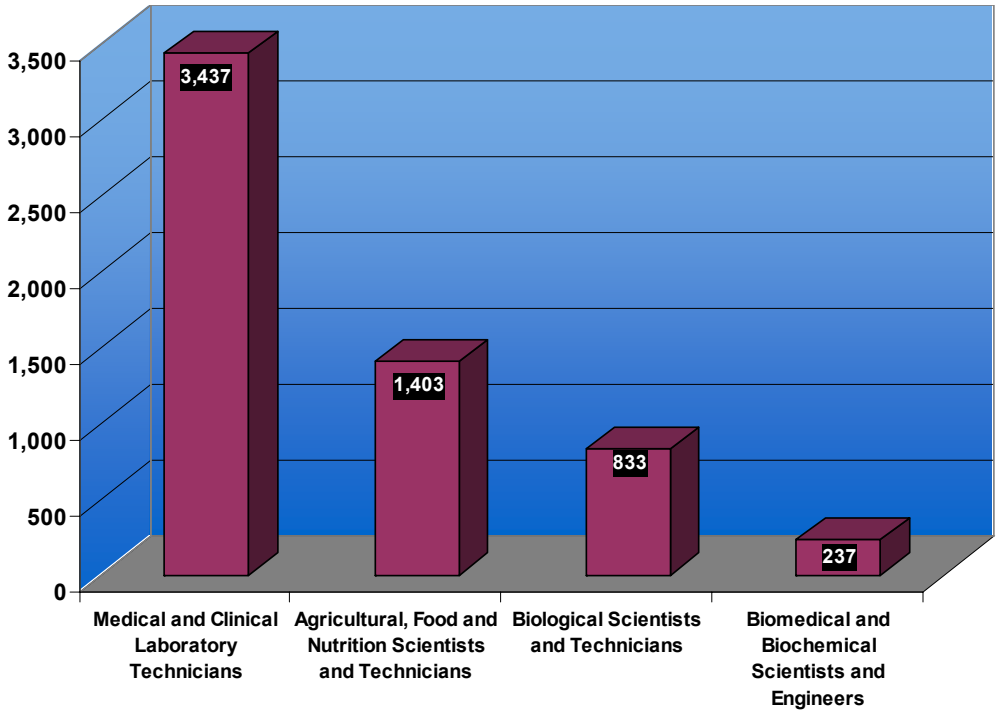
Like any knowledge-based industry, bioscience companies need a supply of qualified and well-trained scientists, technicians, managers, and production and support personnel. Successful bioscience regions contain a critical mass of experienced management and entrepreneurial talent, in combination with sufficient job opportunities to attract and retain world-class researchers, scientists, and technical professionals. Furthermore, these successful regions have coordinated workforce training, skills development, and other programs to provide basic and customized public workforce education in close partnership with industry.

Iowa Assessment. In 2002, Iowa had about 6,000 people employed in biological science occupations, as illustrated in Figure 10. More than half were employed as medical and clinical laboratory technicians. Another quarter were employed as agricultural, food and nutrition scientists and technicians. Fourteen percent were employed as biological scientists and technicians, and 4 percent were employed as biomedical and biochemical scientists and engineers.[10]

The comparatively small size of the commercial bioscience sector, in combination with Iowa's traditionally strong K-12, community college, and university strengths, have proven adequate in supplying the necessary scientific and production talent for bioscience growth. However, it is clear that the base of experienced managers for bioscience companies is thin, and the growth of companies will be limited if experienced management teams are not readily available for start-up and growing enterprises. Also, more jobs are needed in the state to absorb the talent pool graduating from these institutions.

[10] U.S. Bureau of Labor Statistics Occupational Employment Statistics and Battelle calculations, FY 2000–2002. Data are averages of FY 2000–2002 information.

Figure 10: Biological Science Occupations in the Iowa Workforce, 2000–2002



Access to specialized facilities and equipment

Pursuing bioscience advancement takes considerable resources, among the most costly of which are the specialized facilities, infrastructure, and equipment required for bioscience R&D and production activities. The extremely high costs of specialized equipment can rapidly absorb the scarce financial resources of start-up enterprises, placing their development potential and futures at risk. Successful bioscience regions have a variety of specialized incubators, facilities, and supporting infrastructural resources required to meet fledgling company needs. Start-up enterprises are able, in these regions, to lease wet-lab space, rent time on specialized equipment, and access prototyping and piloting resources locally.

Iowa Assessment. Iowa has made considerable progress in this area—with on-the-ground investment in a series of highly valuable bioscience resources (such as GMP facilities, drug development services, animal labs, catalyst development centers, fermentation facilities, virtual reality labs, and biomass conversion facilities). These resources are of great value, and difficult for other states to quickly replicate. Furthermore, Iowa is seeking to expand its resources in this area with new high-level biosecurity and hygienic lab facilities in Iowa City and state-funded bioprocessing facilities on ISU's research park in Ames. It is evident that in plant, animal, and human biosciences, Iowa has some strong infrastructure resources to leverage in support of the core bioscience platforms identified earlier in this report.

In addition, both Iowa State University and the University of Iowa have research parks that are home to a wide array of biotechnology companies. Three incubators affiliated with Iowa State University service biotechnology companies; and the Technology Innovation Center at the University of Iowa fosters new business ventures, including bioscience firms. Two additional incubators are under development in Davenport and Cedar Valley, and the University of Northern Iowa has incubator development plans underway.

Stable and supportive business, tax, regulatory, and incentive policies

Bioscience companies need a regulatory climate and operating environment that encourage and support the growth of their industry. The ideal environment combines tax and incentive policies that recognize the long development cycle required to bring new bioscience discoveries to market, combined with a political environment that expresses a long-term and reliable commitment to the needs of the industry. Business development and growth incentives need to be easy to understand, easy to apply for, and relevant to the specific needs of the bioscience sector.

Iowa Assessment. In Iowa, the state has made considerable progress in formulating specialized business support programs and easing access to them through a single pre-application administered by the IDED. In building a more supportive environment, however, improvements are needed in areas such as tax code and legislative support for cluster initiatives. For instance, Iowa has a technology transfer tax credit that is currently unworkable and needs to be revised in order to be useful in spinning off firms. In addition, Iowa has an R&D tax credit; however, it is not transferable and so of limited value to early-stage bioscience firms that are not yet generating income. Many states assist bioscience firms by allowing them to carry over net operating losses. Iowa could consider these and other initiatives to support the state's bioscience firms.

Patience and a long-term perspective

A short-term perspective will not work in bioscience-based economic development (or in any true effort to build and restructure an economic base). The lesson to be learned from each of the most successful technology states and regions is that success takes time. Silicon Valley and Route 128 trace their origins in electronics to the 1950s and in biosciences to the 1970s. Research Triangle Park represents a 50-year strategy that has only recently found its footing in the biosciences and is still working to develop full capability in the entrepreneurial sector. In contrast, Maryland and San Diego are considered as "coming on quick;" but, both still took 12 to 14 years to really develop.

Iowa Assessment. The building of Iowa as a center for agriculture, farming equipment, and other visible Iowa sectors did not occur overnight—they grew with concerted efforts over many decades to accomplish their national stature. Bioscience development requires a long-term effort to which the state must solidly commit. Due to gubernatorial and legislative leadership, Iowa has emerged as both a large and specialized state in agricultural feedstocks and chemicals, one of five key industry segments that make up the biosciences.

Summary of Key Success Factors

Table 13 compares the lessons learned from the best practices of other states in bioscience economic development with Iowa's current situation.

Table 13: Comparison of Iowa to Best-Practice States and Regions on Key Success Factors

Factors of Success	Best Practice States/Regions	Iowa Situation
Engaged universities taking an active leadership role	▪ Universities are engaged in economic development and committed to technology transfer. ▪ Universities have created vehicles for technology commercialization. ▪ Universities committed to in-state economic impact of technology transfer and commercialization.	▪ Universities appear willing to take a stronger role in economic development, but lack the resources. ▪ Policies, procedures, and perceptions hamper university faculty engagement in start-ups and industry collaboration. ▪ Investment and vehicles required to facilitate technology commercial-ization activity.
Intensive networking across sectors and with industry	▪ Active technology intermediary organizations provide a focal point for state's bioscience and biotechnology efforts. ▪ These organizations play a critical role in networking academic, industry, governmental, and nonprofit groups, encouraging cross-fertilization of ideas and opportunities that lead to joint endeavors. ▪ State has a technology office or senior bioscience advocate to promote industry liaison and support. ▪ Industry environment is such that next-generation spin-offs regularly occur and may be actively encouraged by "parenting" companies.	▪ IBA is small and only has one full-time staff member. Limited in ability to provide wide range of events and interaction opportunities. ▪ BIOWA Development Association is embryonic but is getting industry, academe, and government in alignment on BioEconomy issues and opportunities. ▪ ISU is operating bioscience mixers to encourage industry-to-industry and industry-to-academe links. ▪ There is no state technology office or bioscience advocate. ▪ The few larger bioscience-related companies in Iowa are controlling IP closely and are not generating a major web of spin-offs. ▪ There is no strong history of a university genealogy tree of bioscience spin-offs.

Table 13: Comparison of Iowa to Best-Practice States and Regions on Key Success Factors (continued)

Factors of Success	Best Practice States/Regions	Iowa Situation
Available capital covering all stages of the business cycle	▪ Best practice states and regions have created programs to address the commercialization, pre-seed, and seed financing gaps to help establish firms. ▪ Active informal angel networks are investing in the biosciences. ▪ Established, in-state venture capital firms are investing in biosciences and linked to major out-of-state VC leaders for syndicated investments. ▪ Public and philanthropic investment funds support early-stage business development and assist in bioscience business growth.	▪ Limited pre-seed/seed capital or prototype development funds are available. ▪ Some venture capital and angel investors are in Iowa, but very few are interested in bioscience investments. ▪ National venture capital firms generally lack interest in and awareness of Iowa bioscience investment opportunities. ▪ Limited philanthropic community is not focused on major investment in economic development. ▪ Agriculture-related organizations are able to invest in value-added ag and other agbioscience endeavors. ▪ State Values Fund and additional initiatives support business development initiatives.
Discretionary federal or other R&D funding support	▪ Every major technology region in the U.S. has received significant federal discretionary funding. ▪ One or more federally designated centers exist that serve as anchors for the state's or region's bioscience base.	▪ Iowa universities are gaining a solid share of federal R&D dollars (ranked above state population rank). ▪ Federal investment is being made in animal health facilities (expanding), and opportunities exist in biosecurity. ▪ State and federal support exists for alternative energy and related biomass facilities.
Workforce and talent pool on which to build and sustain efforts	▪ Strong track-record exists in developing internal talent and attracting new talent to the state. ▪ Major base of management talent is experienced in cluster and entrepreneurial endeavors. ▪ Educational institutions at all levels are responsive to the training of students to meet the need for bioscience workers at all skill levels, including scientists, technicians, and production workers.	▪ Historically, Iowa has a high quality of K-12 education, and growing strengths in career academies (although none in biosciences yet). ▪ Very strong community college system is quick to react to the workforce training needs of industry (including bioscience industry). ▪ Very good quality of degreed scientists graduate from regent universities. ▪ Industry expresses satisfaction in ability to recruit scientists and R&D personnel. ▪ Iowa is losing younger adults because of lack of job opportunities and also a perceived lack of "things to do." ▪ Very shallow pool of experienced entrepreneurial talent and start-up managers exists in the biosciences.

Table 13: Comparison of Iowa to Best-Practice States and Regions on Key Success Factors (continued)

Factors of Success	Best Practice States/Regions	Iowa Situation
Access to specialized facilities and equipment	▪ Leading bioscience regions have private markets that provide facilities offering space for bioscience companies. ▪ Specialized bioscience research parks, incubators, and accelerators are common. ▪ Access to specialized facilities and equipment, such as core labs and animal facilities, is readily available for industry and collaborations.	▪ ISU is operating incubators, but they are near capacity. U of I is operating incubator at Oakdale Research Park. UNI incubator is planned. ▪ ISU and U of I incubators are familiar with bioscience needs. ▪ Conflict of interest and other procedural impediments reduce faculty entrepreneurial access to university resources. ▪ Several key facility and equipment investments have been made to support the biosciences, including GMP facilities, drug development services, biomass conversion facilities, chemical catalyst development facilities, bioreactors, etc. ▪ Current interaction between industry and bioscience resources is limited, as is equipment located within regent institutions.
Stable and supportive business, tax, regulatory, and incentive policies	▪ Incentives encourage growth of technology-driven firms through modern economic development tool kit. ▪ Tax structure is designed to encourage and reward R&D. ▪ Government resources, incentives, and funding are easy to access. ▪ Brand name/image established around specific technology areas.	▪ Varieties of economic development incentive and assistance programs are offered through the state, with single pre-app facilitation. ▪ Tax structure, and some incentive structures, is not yet aligned to needs of bioscience or other R&D-based growth technology sectors. ▪ Cost for business operations is reasonably low vs. coastal locations and many other major markets. ▪ Iowa does not yet have an established bioscience marketing campaign, although agricultural heritage and BioEconomy advance-ments are helping on agbiosciences. State is making major commitment to high-profile events, such as Bio 2004.

Table 13: Comparison of Iowa to Best-Practice States and Regions on Key Success Factors (continued)

Factors of Success	Best Practice States/Regions	Iowa Situation
Patience and a long-term perspective	▪ Building a critical mass of bioscience resources and firms occurs over many years or decades. ▪ Companies are built locally, retained locally, and not apt to leave. ▪ Universities, government, non-profits, philanthropies, and industry trade groups are in agreement and alignment on long-term commitment to growing and supporting the sector. ▪ States are willing to accept that cluster development requires geographic co-location benefits and that one or two metro areas may benefit more from the cluster initially until state tax returns can be used to spread benefits throughout state.	▪ Commercial biosciences are a relatively new focus for Iowa except for ag-related bioscience. ▪ Lack of capital is causing some lack of local anchoring of technology start-ups. Movement out of state to follow capital is causing discouragement in Iowa. ▪ No formal alignment or shared strategy on biosciences serves as a driver for Iowa's economic development across all leading organizations and groups. ▪ Lack of recognition of the state-wide agricultural industry as a key element of the state's bioscience industry is compounded by the misperception that only those activities related to university research parks make up the bioscience industry, creating tension regarding funding of key university bioscience investments that will benefit the entire state.

STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS ANALYSIS

This section presents an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) facing the region in building a bioscience sector for the future. This analysis is based on more than 500 interviews conducted with leaders from industry, academia, government, and technology intermediaries, in addition to data analysis conducted earlier. This analysis was accomplished through one-on-one interviews, small group discussions, and focus groups involving leaders throughout the state.

This SWOT analysis follows a methodology similar to a business planning process. In preparing its business plan, a company undertakes a similar exercise, identifying its internal strengths and weaknesses and taking into account and addressing external factors, including markets and opportunities and adverse events and threats. In the following review, Iowa's bioscience base is examined much as a business would examine itself. It should be understood that, in some instances, perceptions of a significant nature have been included. While such perceptions may not be universally supported, they become potential barriers if believed to be true, and therefore must be overcome.

Strengths

The State of Iowa and some of its key communities are recognizing the biosciences as a distinct area of development opportunity and, as a result, are putting in place key initiatives.

The State of Iowa has been quite innovative and flexible in the development of incentive and assistance programs for Iowa industry. A distinct economic development emphasis has been and continues to be

placed on the biosciences as an economic development focus area. Recently, the State of Iowa has allocated significant funding for marketing Iowa as a prime location for bioscience development and business locations. Iowa's government and associated institutions are making progress in providing specific economic-development assistance products and services to encourage bioscience development and commercialization in the state. The Iowa Values Fund, for example, is capable of providing direct assistance to bioscience companies for improvements to space (including leasehold space); and the state has shown unusual flexibility in meeting bricks-and-mortar space needs for companies. Similarly, communities such as Ames and Davenport are examining ways to support and grow bioscience-related businesses, products, and services. For example, the Ames Chamber of Commerce, in collaboration with city and county government and ISU, is promoting Ames as a biotechnology hub. The Iowa Legislature also has been active, introducing 16 bills related to ag-biotech and bioscience, and passing four. The legislation introduced in Iowa has decidedly favored biotechnology, supporting ag-biotech as an important tool that can help Iowa maintain its position as an agricultural leader.

Iowa is addressing current workforce needs and is developing additional programs and initiatives to enhance workforce development, attraction, and retention for the bioscience industry.

Most bioscience firms interviewed indicate that they have been able to find quality workers. This is further confirmed in a recent study[11] by Ruth Consulting of 50 Iowa bioscience firms. Companies indicate that they are experiencing positive recruitment trends, most particularly for scientific and production positions. At the 4-year and graduate-degree levels, both ISU and the U of I are viewed as a source of graduates with a good work ethic and attention to quality; companies have experienced low turnover rates from such hires.

The State of Iowa has been particularly progressive in developing support initiatives for workforce development, including new job training programs that may use tax-exempt bonds and industrial revenue bonds (IRBs) to fund training. Colleges can issue IRBs and then have the debt retired through payroll taxes. Up to 50 percent of on-the-job salary reimbursement during training can be offered. Incumbent job training funding is available up to $25,000 a year for on-site customized job training (using own or hired instructors). The 260G program provides funding for workforce enhancement in new areas where skill gaps in the Iowa workforce are identified or expected to occur, with 20 percent of the training cost paid by industry, and the remaining 80 percent supported through a grant program and diversion of payroll taxes from existing workforce payments. In addition, IDED's Human Resource Consortium is working to recruit people back to Iowa. This professionally operated program is holding national events in which the Governor participates. Using alumni lists provided by state universities, IDED is building a database of 14,000 alumni interested in receiving further news and information about Iowa.

Iowa also has placed an emphasis on support for 2-year programs and workforce skills training, a process facilitated by the large and innovative community college system. Workforce education and development in Iowa benefits from a strong and dynamic community college system, which comprises 15 institutions. Iowa's community colleges serve a broad constituency. For example, Kirkwood Community College has 15,000 students, making it the third largest higher education institution in Iowa. Between 87 and 90 percent of community college graduates remain in Iowa after graduation.

[11] Swim, Bill, Ph.D. *A Training Needs Assessment of 50 Iowa Biotech Companies.* Ruth Consulting Group Limited for the Iowa Department of Economic Development. 2004.

Technology infrastructure, including research parks, incubators, and other commercialization space, exists, particularly around research universities; although unmet needs remain.

Both the University of Iowa and Iowa State University have research parks close to their main campuses (ISU's park is adjacent to the campus, while the U of I park is at Oakdale, 8 miles from the main campus). In both cases, these research parks contain incubator space.

In addition to the incubators, access to space for business start-ups at the regent universities has been and continues to be addressed. ISU has demonstrated flexibility in allowing limited use of main campus lab space and facilities in the earliest stages of research commercialization. ISU also maintains new incubator space for plant sciences ventures within the Carver Co-Lab. The main ISU incubator at the research park contains 8,500 square feet of space, all of which is currently full. But, other university and non-university communities have technology infrastructure issues that need to be addressed.

Iowa's research universities show strengths in a number of technology platforms for both the short and long term, and both faculty and administrative interest exists in partnering with industry in technology transfer and commercialization efforts.

Within the academic R&D arena, the state is performing particularly well in the biosciences, with 66 percent of all academic research funds falling under this definition. This level of performance places Iowa 21st in the nation. Iowa's rankings in the three major macro-categories of bioscience R&D are 19th in medical sciences, 20th in agricultural sciences, and 22nd in biological sciences. While in all three cases Iowa's performance exceeds its ranking among the states in population, a higher ranking in federal funds for agricultural sciences might be expected given the state's strengths in agriculture.

Iowa has significant promise to be among the nation's bioscience research leaders in selective fields. Iowa institutions have substantive strengths in the "three legs of the bioscience stool"—plant, animal, and human biosciences. In particular, the bioscience operations of both ISU and U of I show fundamental strengths in bioscience technology platforms that can be further enhanced by increased collaborations between the institutions and with industry.

Both ISU and the U of I have made considerable progress in structuring their programs, projects, centers, and initiatives to facilitate the commercialization of innovation. The Kaufmann Foundation has provided limited funding to an ISU planned initiative to utilize experienced faculty entrepreneurs as mentors to other faculty start-ups. ISU has allowed companies to start on campus and provided access to laboratory space for preliminary needs, while also facilitating more formal relationships at the ISU incubator and co-lab facilities. ISU's interest includes working with existing bioscience firms in terms of expansion and new product development. For example, Proliant (while not a university-related start-up) has had excellent access to ISU resources, including using labs, renting pilot space, and performing collaborative studies.

The ISU Extension activities play a very important role in linking the university and its pragmatic research discoveries to the agriculture, processing, and industrial sectors. The ISU Extension is a substantial $78 million operation and impacts critical areas of the Iowa economy through the operation of multiple services, including the Iowa Manufacturing Extension Partnership, the CIRAS, Extension to Agriculture and Natural Resources, 4-H youth development, and a broad suite of continuing education and communications services.

The U of I Law School, College of Business, and College of Medicine are working to form a biomedical venture group with faculty, staff, and students to help faculty move their commercialization concepts

forward. The U of I College of Medicine has appointed one of its physicians (an experienced entrepreneur) as Director for Economic Development and is actively engaged in preliminary work to encourage entrepreneurship and provide mentoring through experienced faculty entrepreneurs.

The State of Iowa has a broad and growing base of bioscience companies, many of which have high profiles in their respective bioscience sectors. Companies such as Pioneer in agricultural biotech and Fort Dodge Animal Health in veterinary medicine help to place Iowa on the bioscience corporate radar.

Almost 83,000 people were employed in the biosciences in Iowa in 2002. Three bioscience subsectors, organic and agricultural chemicals, agricultural processing, and agricultural machinery and equipment, are well positioned to be the foundation of a comprehensive economic-development strategy. Medical-related subsectors, though not yet core strengths, demonstrate characteristics that place them in the category of emerging potential drivers. Above-average employment growth relative to the United States indicates that these subsectors can be crucial parts of the bioscience industry's future.

In addition, the bioscience industry is geographically dispersed across the state. While bioscience companies are concentrated in the Ames–Des Moines and Iowa City–Cedar-Rapids corridors, the bioscience commercial sector is quite broadly distributed geographically in the state, with companies as far afield as Sioux Center and Eddyville.

Iowa's long-term history in industrial and agricultural production provides an infrastructure and resource base suited to the support of certain bioscience platforms.

Iowa is well positioned and structured to provide efficient distribution of the bulk and specialty products that result, or may result, from the BioEconomy initiatives. The state has in-place infrastructure that currently carries bulk chemicals and agricultural commodities from the state to external processing locations—a resource that will be equally useful for chemicals, fuels, plastics, and fiber from biorenewable resources and for advanced food ingredients and finished products from the Advanced Foods and Feed Platform. Iowa's agricultural heritage also provides multiple advantages for bioscience development, including convenient access to bulk biomass feedstocks and a growing expertise in value-added product production from agricultural raw materials and resources. Iowa has great state pride in its agricultural heritage, and the ag-biosciences (both plant and animal) are a natural technology pathway for building upon this strength and legacy of expertise. Iowa also has been a leading adopter of new technology in agricultural production, and its primary agricultural production and ag-processing sectors are technology savvy.

Iowa provides a stable quality of life that holds appeal in a time of change and uncertainty.

Iowa is a state of small towns and cities with a small-town feel. The state enjoys a comparatively low cost of living, low crime rates, short commuting times, and an excellent public education system. People seem to put down roots in the Midwest, and the state is having considerable success in winning people back who had once left to pursue opportunities on the East and West Coasts. There is a sense of place in Iowa that evokes longevity and security, an atmosphere that may be intangible but nonetheless valuable in an American society that is increasingly stressful and perhaps insecure. Iowa also is an egalitarian state in which no single place dominates state politics and progress—it is a place of dispersed population, employment, and resources.

Weaknesses

To take full advantage of its research base, Iowa needs to find ways to address a lack of experienced bioscience entrepreneurs and managers who can fulfill management duties in new start-ups or provide mentoring to new bioscience enterprises.

Lack of experience makes new businesses a more high-risk venture and makes the attraction of seed and venture capital that much more difficult. Because a fully mature cluster of firms with successful role models that have grown to become mid-sized and larger firms has not yet occurred, most firms are still small in size and have few experienced resources and support structures. There is a relative lack of experienced serial entrepreneurs with bioscience company expertise available for hire by start-ups and growing small firms. Instead, these seasoned professionals have to be recruited from outside the state, whether as chief executive officers, chief operating officers, chief financial officers, or in senior sales and marketing positions. **Overall, Iowa lacks an ingrained entrepreneurial culture that encourages and rewards risk taking.**

Furthermore, such firms need and desire more mentoring and advice. While the Pappajohn Centers are in the coaching business, they are insufficiently staffed and lack the depth of experienced bioscience entrepreneurs to offer in-depth assistance. Companies interviewed cited the Pappajohn Centers as useful for performing market research and other basic tasks and also for providing access to interns for bioscience companies.

There is lack of sufficient wet-lab space in some areas of Iowa, particularly for seed and pre-seed stage entrepreneurial endeavors.

In one sense, the unmet demand for space is a positive sign of growth and development. On the other hand, even more mature bioscience regions of the country face challenges in offering sufficient lab space. Access to university lab space could facilitate early-stage commercialization investigations; but, legal, financial, and other community factors restrict such access. In addition to the problem of available space is the location of that space. Particularly with research and testing and drug and pharmaceutical firms, entrepreneurs want to be close to medical schools and centers. The U of I research park/incubator, for example, is perceived to be too distant from the university.

The perception among entrepreneurial faculty, investors, and bioscience industry leaders is that Iowa university-based entrepreneurial activity and momentum are being constrained by mixed institutional messages and support for the biosciences, including its commercialization in the state.

Universities feel the pressure from the state to be economic development engines, but do not believe they are receiving the support required to facilitate this enhanced mission. Higher education state funding is down $105 million, or 15 percent, since FY 2001, and the line item for economic development that has supported much of the technology transfer and commercialization efforts at universities has been reduced by more than 60 percent in the same time period. These cuts are seen as limiting the ability of the universities to respond to the commercialization challenges and criticisms regarding entrepreneurial support and assistance capacity.

While varying among the research institutions, and most strongly expressed at the University of Iowa, concerns were expressed with Board of Regents policy and direction. Faculty does not perceive an institutional imperative to commercialize their research and see little incentive to do so. As a result, there is a relatively low volume of entrepreneurial faculty coming forward at the regent universities. While bioscience-based economic development is understood by many in academia to be a key priority for the

state, faculty remain unsure of the seriousness of the state commitment given the current restraints and barriers, whether they be starting spin-off firms or commercializing their intellectual property.

Encouraging the state's researchers to assist in economic development will require changes in university internal reward systems and require appropriate peer approval and recognition. Some of the key issues that need to be addressed, as identified in the interviews, include the following:

- Access to space for firms and for technology commercialization
- Change in policies to allow for academic release time to pursue entrepreneurial endeavors in addition to academic recognition regarding leave for entrepreneurial pursuit
- Conflict-of-interest/conflict-of-management policies, their interpretation and management
- Timely disposal and response to disclosures, patents, and licensing decisions
- Lack of commercialization tools, such as market and technology assessment support and prototype development funds
- Limited support in finding licensees of intellectual property
- Willingness to offer cutting-edge approaches to partnering with industry, e.g., taking equity rather than fees/royalties, start-up licenses, etc. (Note: While supposedly permitted to take equity, the universities report few instances in recent years of doing so, even though this is an accepted national practice in public as well as private research universities.)
- Lack of state-based pre-seed/seed financial support.

Resources appear insufficient to allow the technology transfer and licensing operations of Iowa's public universities to move at a "commercial pace." Companies and entrepreneurs raised concerns regarding multiple cases in which processes took many months to advance.

As is true of most public research universities in the country, technology transfer at Iowa universities has limited staffing and resources. This results in an inability to move as quickly as the technology transfer professionals might desire because of large workloads. It also means some important but not critical work, such as identifying partners, conducting outreach, and providing support for the SBIR program may not be conducted. Major issues appear to be related to (1) amount of time taken to process intellectual property disclosures and reach decisions; (2) university efforts to place too high a value on only the research, resulting in protracted negotiations; and (3) a perceived conservatism and fear that after home runs happen, the university will be accused of failing to capture the full value.

As the AUTM data indicate in Table 9, Iowa's universities perform in the median of all universities and, in several instances, even outperform the top quartile of all universities. But, the metrics do suggest areas for improvement such as licensing of start-ups by all Iowa institutions and indicate variation among institutions on the other measures. Furthermore, it is not the general practice for universities currently to take equity positions in companies in return for providing a low license and royalty on intellectual property. However, there appears to be ambiguity about how and whether universities can take equity. ISU's ISURF believes it can take equity in lieu of license fees and anticipates becoming more active in the future. In addition, UNI Research Foundation has begun taking equity stakes in start-up ventures. The State of Iowa is not able to take an equity position in a company since there are constitutional restrictions on such activity; creative ways are required to overcome this problem. Both Arizona and

Utah have amendments on their Fall 2004 ballots for voter approval to enable universities to take equity in their intellectual property, and Oregon voters passed a similar measure in the Fall of 2003.

Overall, successful commercialization of bioscience discoveries and technologies in Iowa may require a comprehensive review of policies and relaxed return expectations at the IP-generating universities. By adopting policies that are more flexible for companies forming and operating in-state, the regent universities may enhance the market value of this intellectual property, attract additional research stars who are increasingly attracted to opportunities for commercialization, and further contribute to the state's economic future.

Capital gaps for the biosciences exist, with the biggest gap being in the pre-seed and seed stages of support (investments less than $2 million).

On the commercialization front, financing for start-ups, spin-offs, and younger bioscience firms has been difficult to secure in Iowa. There is an evident lack of pre-seed, seed, and venture capital available in Iowa to fund new ventures in the biosciences. Lack of local capital resources is limiting entrepreneurship on campuses and reducing the volume of innovation-based companies in the state. The scarcity of venture capital was confirmed in interviews with multiple start-up companies in the state.

Research leaders throughout the state note a significant need for seed capital and pre-seed funds. Because Iowa's venture capital firms are not interested in the very early seed stage—instead they are mostly active in the second and third venture capital rounds for companies that have reached market and a certain threshold of success—capital availability for start-up enterprises is scarce. Some local angels have been involved in university-originated start-ups, but the volume of activity is quite limited. Seed funding organizations (angel networks, community seed funds, etc.) are not coordinated or well connected and need mentoring and investment guidance to make bioscience investments. While the State of Iowa has numerous programs that provide incentives through tax credits to companies, they do not appear to be well structured for bioscience firms that are not generating taxable income in the near term.

None of the Iowa-based venture capital firms interviewed by Battelle were able to name a venture-backed bioscience company in Iowa that has gone on to be a substantial growth success, e.g., role model. In addition, some former players in the biotech and bioscience venture capital arena are now no longer interested in this sector. To maximize their limited investment dollars, several Iowa VC firms are making many investments in out-of-state deals. The largest fund interviewed, for example, only has three Iowa investments out of a total of 13.

Finally, while the largest public pension fund in Iowa does invest in venture capital, it utilizes discretionary professional managers who select the funds for investment. There is no specific focus on the biosciences or on investments in Iowa. Deals in Iowa are forwarded to the funds for consideration, but there is no state-enacted incentive or investment guarantee to address fiduciary concerns. Several other state pension funds (Pennsylvania, Maryland, Oregon, California, and Wisconsin) have become involved in efforts to accomplish the dual objectives of targeted investments in the biosciences and attention to in-state firms in ways that are consistent with their respective fiduciary standards of return on investment. Iowa's public pension fund may wish to examine ways, working with its discretionary professional managers and reviewing the experiences of other state pension funds, in which it might contribute to addressing the capital gaps facing bioscience firms in the state. This must be done in accordance with its policies, legislative base, and stated return-on-investment policy.

Recent state initiatives to address capital gaps, including formation of a fund of funds, the Iowa Values Fund, and tax incentives for investors, should better position Iowa to secure sufficient funding for these bioscience ventures in the future. Specifically, IDED is offering the following innovative programs to assist firms in accessing state programs and capital resources:

- A single pre-application for assistance that serves to inform IDED staff who will work to find the right package of state programs to meet company needs.
- The Iowa Values Fund, which includes business development and assistance for start-ups or expansions as part of its core focus.[12]
- The Iowa Fund of Funds, an initiative formed under legislation to create the ICIC and the ICIB. ICIC is working to build the Fund of Funds, which will be organized as a private, for-profit limited partnership, authorized to make investments in private venture capital funds (which must have or commit to establishing a base of operations in Iowa). In addition, ICIB has been established to oversee the issuance of tax credits to guarantee, at least partially, investments in the Fund of Funds.
- Capital availability via the use of the insurance company premiums tax to serve as funding sources for addressing some of the capital gaps for the biosciences.
- The Entrepreneurial Ventures Program, which provides up to $250,000 for royalty repayment funding or use in the acquisition of intellectual property.
- The Iowa Agriculture Innovation Center, which is operating under a $1 million, 1-year grant from the USDA and a $500,000 match. The program is producer and innovation focused, providing services in business plan preparation (under contract with small business development centers [SBDCs]), raising interest in value-added products, and creating a "blue book" showing all uses for each commodity. The Center's work concentrates on the processing end of the chain (in projects that are at least 51 percent producer owned).

The State of Iowa also has limited philanthropic resources available to finance bioscience initiatives and commercialization endeavors. John Pappajohn has been generous in his funding of entrepreneurship development centers; but, for the most part, Iowa lacks a strongly committed philanthropic sector with a history of involvement in the state's economy. In other states, such as Pennsylvania, Arizona, and Missouri, private foundations have been instrumental partners in supporting bioscience and other technology initiatives.

The tools to support the commercialization of the state's research and technology base are not fully in place or developed, such as prototype development.

The institutions see a need to help faculty entrepreneurs with commercialization research, prototype development, market studies, etc., which can help "de-risk" their potential projects. However, the institutions do not have financial resources to provide the type of services required**.** Faculty needs resources for proof-of-concept work to determine whether a technology has commercial potential. This activity is not supported by academic research dollars and is too "basic" for outside industry support. There is thus a "moving forward" gap that prevents many potential university technologies from progressing beyond the intellectual concept phase. It should also be noted that Iowa's universities are inclined to be driven and to measure their own success by the amount of federal funds and the indirects

[12] Other emphasis areas for the Iowa Values Fund are in university research and development, workforce training, quality of life, and school infrastructure.

they generate—not by meeting the specific R&D needs and corresponding commercial opportunities they present for the state.

The emerging bioscience industry cluster in Iowa is not as well connected, supported, and assisted as it needs to be.

The Iowa Biotechnology Association is a very small operation and is quite limited in the activities and support services it can sustain from membership dues. BIOWA is a newer organization particularly focused on biorenewables, but the two organizations have only recently begun to work together. Bioscience companies in Iowa do not yet seem to be well connected to or networked with one another. Companies interviewed in group settings did not seem to know of one another's capabilities. While there is a cluster of bioscience companies in the rectangle formed between Des Moines, Ames, Cedar Rapids, and Iowa City, many Iowa bioscience companies are scattered in isolated areas around the state (making communications, networking, and access to specialized help difficult to obtain but even more important). Also, many bioscience companies in Iowa seem to lack ambition to grow beyond 10 or so employees. According to Ruth Consulting, scientist entrepreneurs found they could no longer manage the company beyond this point and so deliberately limited growth to remain a small business rather than being entrepreneurial driven, wanting to become a giant.

While Iowa has a strong and innovative community college system, gaps remain that need to be addressed if Iowa is to have the talent pool essential to address the needs of this growing but diversified set of industries.

The cost of lab space for customized bioscience programs is a challenge for community colleges, and ways must be found to support specialized high-cost programs in the biosciences. A critical mass of customers is needed to justify the investment, a critical mass that exists in few places in the state. There is no bioscience career academy formed in Iowa. Poor levels of articulation exist between community colleges and the regent universities (particularly U of I, which will accept few community college credits in its biology program). Further ways must be found to encourage more terminal degree technician programs in the biosciences to meet industry needs. Currently, nearly one-third of vocational technical students transfer to 4-year institutions. An excellent model, the Eddyville Biotech Training Center, could be better used throughout the state by offering complex core courses on-site and linking to community colleges statewide for general coursework.

Iowa does not have a strong track record in many of the industry sectors that relate to, support, or can spur growth in some of the bioscience core platform areas.

Both the BioEconomy and Advanced Food and Feed Platforms are naturals given the breadth and depth of Iowa's academic expertise and the primary production resource base for raw materials and feedstocks to these sectors. However, in moving up the value chain, Iowa faces challenges because it is not a major center for chemical products manufacturing, plastics, or other "value-added" BioEconomy products, nor is it a center for food processing and the manufacturing of finished food products. While Iowa has strong R&D expertise related to drugs, biologics, and other human and animal medical products, it also lacks a strong industry base in these fields (except in veterinary products).

Iowa's state business incentives, tax policies, etc., have not yet been geared to the explicit support of bioscience sector growth.

In recent years, the state has enacted a number of changes in its economic development "tool kit" to address the needs for venture capital, the need to have funds to invest directly in firm product

development (Iowa Values Fund), and other measures. Although much has occurred, current state policies and incentives are still designed to favor projects that create a significant number of jobs (no matter what the quality of those jobs may be). Modern technology-based economic development, however, benefits more from incentives aimed at R&D and wealth creation, and at job quality as opposed to quantity. Incentives and policy still appear to favor "brawn-based" manufacturing jobs over the types of employment at the forefront in the innovation economy.

Opportunities

Iowa may be in a good position to attract the serial entrepreneurial management (including sales and regulatory) back to Iowa to help grow its bioscience cluster.

New Link Genetics in Ames, for example, has had a good experience in working to attract M.D.'s and Ph.D.'s to move to Iowa, with many of the scientific staff being recruited from the National Cancer Institute in Bethesda, Maryland. It appears that the nation contains a significant volume of people who are attracted to return to the family supportive environment and livability of the Midwest. The State of Iowa is a recognized national leader in actively facilitating the attraction of these "returnees" through specialized recruiting and promotional initiatives, and these efforts could be used to give greater focus to the biosciences.

Iowa has an opportunity to market and brand itself broadly in the biosciences with strengths in animal, plant, and life sciences that can increase its bioscience visibility in several markets concurrently.

It is important that all "three legs of the bioscience stool" be recognized as integral to the future economic growth of Iowa, namely human, animal, and plant biosciences. Agricultural biosciences have much higher legislative and public visibility in the state than do human medical sciences. While it is good that agricultural bioscience is recognized for its significant value to the current and future health of the Iowa economy, it is not good to have a weaker understanding of the strong position of Iowa in human bioscience R&D.

Bioscience start-up successes currently get very little press or celebration in Iowa or elsewhere. Even within the research community, university spin-offs are not events that have garnered much positive feedback or recognition.

Iowa has the opportunity to build on its technology and research strengths by developing private-public partnerships in technology commercialization to address critical gaps.

Angel and seed financing, SBIR support, and prototype development might be related functions and activities that can be organized through a nonprofit with a for-profit arm to share some of the costs and expertise needed, such as due diligence and market intelligence. These activities focused on technology commercialization can complement technology transfer in the research universities. The state's co-ops and trade associations might consider investing a portion of their "check-off" dues into forming and operating these technology commercialization engines as well. The St. Louis BioGenerator is an example of the private and public sectors coming together to form such an organization, although its charge does not include all of the items listed above. Other examples include Baylor Medical Ventures and the Oklahoma Technology Commercialization Center.

Iowa, through the Board of Regents and the Iowa Values Fund, is allocating some funds to address steps necessary for building research platforms to help ensure their competitiveness nationally and globally.

The State of Iowa is funding some specific initiatives at the regent universities with an eye toward bioscience-based economic development**.** From the Iowa Values Fund, $25 million has been allocated to fund a biologics facility for plant proteins at Iowa State University, expand wet-lab space at the University of Iowa's Oakdale campus, and establish an innovation accelerator and incubator at the University of Northern Iowa. The Board of Regents also has a proposal to the Iowa Legislature to raise funds for infrastructure improvement at the universities, including life science instructional programs.

Iowa has a base of firms, universities, and business service providers beginning to work together; and these existing relationships present an opportunity upon which to build.

One concrete example of networking to address the capital availability gap is already underway. IDED has initiated a forum for bringing together venture capitalists and angels, and there may be a $60 million potential for raising investment funds from the insurance industry in Iowa (the state's insurance companies reached an agreement with the Governor to use a premium tax reduction to fund $60 million in venture deals). There also may be potential to engage the larger Iowa companies, such as Pioneer, etc., in forming an investment fund for early-stage bioscience ventures.

It also should be noted that several venture capital firms in the state seemed unaware of the smaller bioscience firms in the state that have moved beyond R&D and have small markets for their products. As a result, there is an opportunity to create an event in which the smaller (circa 10 employees) bioscience firms in the state can be introduced to potential partners and venture funding sources.

Finally, the IBA and BIOWA are beginning to collaborate and discuss shared roles.

Iowa has an opportunity to take greater advantage of its federal labs and facilities to build its bioscience future.

Iowa has the National Animal Disease Lab located in Ames that may further advance the state's position on technology platforms. Experiences elsewhere show that such federal facilities are critical in building bioscience-driven economies. Discussions to further link the state health lab and the Center for Disease Control and Prevention are underway, and there is always an opportunity to work with the state's Congressional Delegation and others to secure federal funds strategically to implement this bioscience strategy.

Economic trends impart a sense of urgency and favor Iowa's progress on BioEconomy and other initiatives.

The historic highs being reached in fossil fuels, petroleum-based gasoline, and related chemical products favor those in Iowa who have invested in biorenewable alternatives. In the near term this may increase cash flows and capital availability for expanding these industries, while in the mid- to long term the vulnerability of U.S. economic security to foreign oil supplies may engender further federal support for biorenewable resource development and associated technologies. Iowa's strengths in infectious diseases, agricultural and food safety, and other related fields also provide a strong position for economic advances based on biosecurity and agrosecurity federally funded initiatives. A rapidly growing world population and an increasing focus on human health and nutrition also favor Iowa's platform development in advanced food and feed and animal systems.

Historically, Iowa has had an agricultural sector that quickly adopts and applies technology breakthroughs and thus offers a good business climate in which transgenic and genetically modified organism (GMO) work can be undertaken on a pilot or demonstration basis.

While Europe, Asia, and even parts of North America react to unscientific threats and perceptions regarding dangers from GMO products, Iowa has a window of opportunity, based on a realistic and pragmatic approach to genetics and transgenics, that may facilitate its development and cementing of a leadership position in a clear growth field. Iowans are taking a scientific approach to the commercialization and use of transgenics, but also doing so with attention to risk evaluation and mitigation. Indeed, it is in Iowa that protocols for transgenic security and product handling are being developed—protocols likely to be accepted as standards on a world stage.

Threats

State financial support, due to declining state revenues, has reduced the ability of Iowa's research universities to position themselves as globally competitive in the biosciences.

State government financial support has declined significantly during the past 5 years. The result has been program cuts, faculty salary freezes, an inability to invest in new technologies and infrastructure, and a general fear for the future among the Iowa education and scientific community. At a time when higher education research institutions represent a strong economic investment, Iowa has had to reduce rather than increase investment. A lack of sufficient state funding could put at risk some of the core strengths and resulting technology platforms. In recent years Iowa's total growth in bioscience funding has not kept pace with that of the nation, resulting in a slightly declining bioscience R&D market share of total academic R&D.

Iowa's state budget has caused a decline in funding to the regent universities. This, in turn, has caused the universities to cut any programs and initiatives that are not central to their academic research and teaching missions. Economic development, entrepreneurship, and commercialization activities that are crucial to the state's economic future have been major components of the cutbacks. Continued declining funding for the regent institutions will continue to restrict their ability to efficiently perform commercialization, technology transfer, business assistance, and other services contributing to entrepreneurship and technology commercialization in Iowa.

It also should be noted that Iowa's state financial situation may improve as commodity prices increase. With more freedom to allocate financial resources to higher education and the regent universities, Iowa may run the risk that its research universities will see fewer imperatives for engaging in economic development and revert to more traditional academic pursuits.

Effective partnerships among the bioscience industry, higher education, and the public sector are not fully optimized, resulting in potential firms, talent, or technology seeking opportunities elsewhere.

In the past, firms have felt that announced partnerships have not fully blossomed; and concern exists that a similar fate will await the implementation of an Iowa Bioscience Strategy. If this were to occur, it would set back critical private-sector commitment and interest by many years, perhaps even fatally, as there are narrow windows of time and opportunity in many of the markets Iowa seeks to penetrate. A number of interviewees expressed concern that, if Iowa's private and public sectors do not step up to the plate, existing as well as newly established biosciences firms are likely to migrate elsewhere. Issues of capital, space, and business climate must be adequately addressed and deep ties made between bioscience firms and the state's indigenous resources to make future migration less likely.

Other states are aggressively pursuing bioscience development.

All 50 states have one or more initiatives to support the development of the biosciences, and at least 26 states have targeted the biosciences. Ohio's Third Frontier effort, with more than $1 billion in state funds, has awarded funds to six centers to date, half of which are in the biosciences. The State of Florida and a county have announced a commitment of $510 million to build a new Scripps Research Institute in South Florida. States have provided funds (such as Arizona providing $440 million) for new bioscience research facilities in their state. Unless Iowa makes ongoing commitments for the facilities, faculty, and technology transfer it needs to optimize the benefits of its technology platforms, it may lose its competitive advantage.

Competitiveness among higher education institutions could adversely affect the state's bioscience potential as other universities are pursuing the biosciences as a key area of focus for their future.

Just as states are investing in the biosciences, so are higher education institutions, many of which are offering sizable packages to attract star and emerging star faculty to their universities. Again, Iowa could be placed in a noncompetitive position were it not able to retain its stars as well as recruit stars for the future through endowed chairs, adequate facilities and equipment, and recruitment packages that ensure competitiveness. In the highly competitive arena of the biosciences, where national universities are working hard to attract top talent, Iowa's human capital strengths in university-based bioscience R&D could be lost to other states. Faculty and scientists may be attracted to higher-paying jobs and more richly endowed laboratories and facilities in states where investments continue to be made in spite of revenue shortfalls.

Other states may have a more entrepreneurial, risk-taking culture and are more willing to invest now for the long haul, resulting in firms starting or growing elsewhere rather than in Iowa. Other regions may be able to address the need for risk capital or technology commercialization more quickly and with more commitment than Iowa.

The bottom line is that good research and research reputation matters, but so does the creation of firms and jobs that directly or indirectly come from these research engines. Iowa must address some key gaps crucial to building not only critical mass of research but a critical mass of firms in the biosciences, including wet-lab space, technology commercialization support, angel and seed capital, and technology connected to firm and wealth creation.

Bioscience Strategies and Actions

As previously noted, it is technology-based economic development, driven by innovation, talent, and investment capital, that is shaping the future of successful U.S. state economies. Therefore, if Iowa is to succeed in developing a bioscience-driven economy, it must ensure its competitive position in three ways:

- Iowa must nurture bioscience research within its core platforms and encourage and facilitate the movement of R&D into new entrepreneurial bioscience enterprises and existing firms, thereby helping to ensure that its bioscience industry is constantly focused on **technological innovation**.
- Iowa must have the **talent** base of knowledgeable workers at all levels—from technician to postdoctorate—that can develop and apply knowledge to the advancement of bioscience developments.
- Iowa must have **capital markets** receptive and prone to investing in innovative firms and entrepreneurs developing and applying cutting-edge technology to bioscience products and processes.

The following strategic plan has been designed to be driven by industry and capitalize on Iowa's comparative bioscience advantages, while ensuring that future investments are focused on building the technology, knowledge, and capital that will ensure Iowa's economic success for years to come.

VISION

With strong public-private leadership and long-term commitment on the part of Iowa's research institutions, business community, nonprofit community, and state and local governments, it is reasonable to expect that Iowa can achieve the following vision by 2014:

> ***Iowa is a leading Midwestern state with a comprehensive set of strengths in the plant, animal, and human sciences. Iowa is a leader in the application of biorenewable resources to create value-added products and has become a significant player in the production of advanced food products, drugs, biologics, and related biomedical technologies. The Iowa biosciences are characterized by strong public-private and industry-university relationships, resulting in a strong base of bioscience companies operating in Iowa in the development and production of plant, animal, and human bioscience products.***

MISSION

To achieve this vision, Iowa must approach its future in the biosciences by focusing on the following:

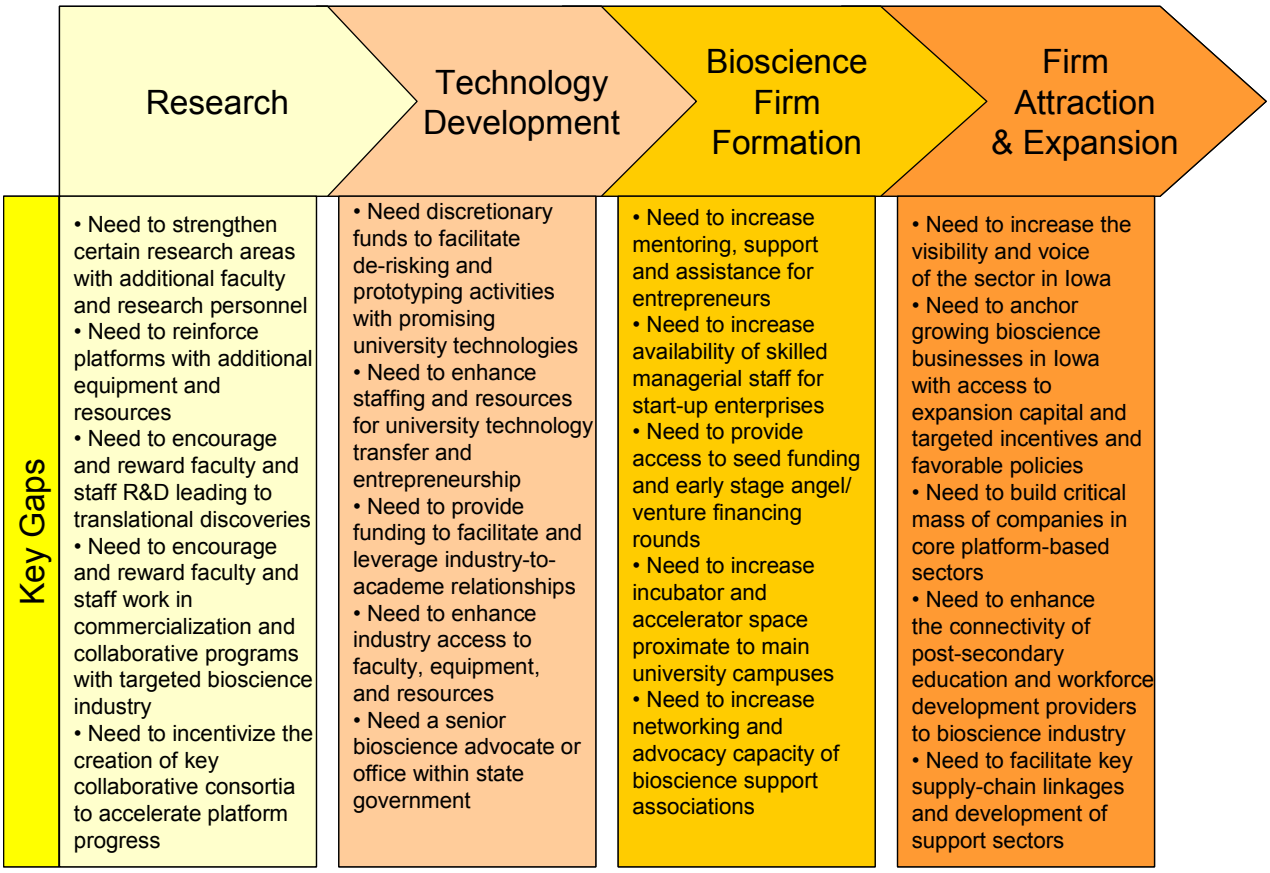
- **Investing in the further development of key R&D platforms at Iowa's regent universities**, including facilities, equipment, scientific resources, and the attraction and retention of Eminent Scholars and their research teams to generate commercializable innovations from these investments.
- **Putting in place incentives, programs, and organizations that will facilitate and encourage the translation of bioscience innovation into products, processes, and other mechanisms of economic value and wealth creation for Iowa**.

- **Securing capital funding sources** that will provide the financial resources necessary to move innovative technology from the research bench to commercialization and into fully fledged entrepreneurial businesses growing and expanding from their base in Iowa.
- **Applying itself to the creation of an educational, economic, and social environment conducive to the creation, attraction, and retention of human talent** at all key bioscience business skill levels—from R&D scientists to experienced management and production personnel.

Gap Analysis

For Iowa to achieve its mission and accomplish its bioscience economic development vision, several key issues will need to be addressed. These issues represent current gaps in creating an integrated, wealth-generating continuum that begins with R&D and culminates in full-scale and ongoing bioscience business operations. Figure 11 summarizes the key gaps that must be addressed in order to realize Iowa's bioscience development potential.

Figure 11: Iowa's Key Gaps Along the Biosciences Development Continuum



The following section proposes strategies and actions to address and fill these gaps.

STRATEGIES AND ACTIONS

While Iowa has considerable existing strengths in the biosciences and significant platforms upon which to build bioscience economic development, assistance and action are required to realize the development potential and advance Iowa ahead of its competition. As the SWOT and gap analyses identified, Iowa has some significant weaknesses to offset and gaps to fill in order to optimally advance the biosciences as a key driver of the Iowa economy.

For the biosciences to realize their potential as a major economic engine for Iowa, the state must simultaneously address both the strengthening of research drivers and the efficient development of commercial enterprise from research innovations. Four strategies have been identified that will entail 20 associated actions to further develop Iowa's bioscience research base and build a critical mass of bioscience companies.

- **Strategy One:** Build Iowa's bioscience research capacity around selected technology platforms focusing on investments in talent, facilities, and equipment.
- **Strategy Two**: Encourage and facilitate the commercialization of bioscience R&D to enhance opportunities for start-up, emerging, and existing Iowa firms.
- **Strategy Three**: Foster a business environment that supports, sustains, and encourages the growth and sustainability of bioscience firms in Iowa.
- **Strategy Four**: Invest in and develop Iowa's bioscience talent pool.

These strategies and associated actions are summarized in Table 14, followed by a detailed narrative description and explanation on subsequent pages. Implementation of these strategies and actions is anticipated as a 5-year period. *Immediate* priorities should be undertaken in the next year to 18 months, *short-term* priorities in 18 months to 3 years, and *mid-term* priorities in 3 to 5 year time period.

Table 14: Iowa Bioscience Strategies and Actions

Strategy	Actions	Priority
Strategy One: *Build Iowa's bioscience research capacity around selected technology platforms focusing on investments in talent, facilities, and equipment.*	▪ **Undertake key recruitment, capacity building, and required investments to ensure rapid scientific progress in the core bioscience platforms.**	Short-term
	▪ Create an **Endowed Chairs Program** to attract world-class, entrepreneurial talent in the core bioscience platforms.	Short-term
	▪ Form a **Strategic Technology Platform Infrastructure Fund** to strengthen and accelerate the scientific and commercialization work of the core bioscience platforms.	Short-term
	▪ **Engage Iowa's Congressional Delegation** in discussions pertaining to federal funding and specific project support.	Immediate
	▪ Institute an industry-university **matching grant program dedicated to the identified bioscience technology platforms** to encourage relationships between academic researchers and industry.	Immediate

Table 14: Iowa Bioscience Strategies and Actions (continued)

Strategy	Actions	Priority
Strategy Two: *Encourage and facilitate the commercialization of bioscience R&D to enhance opportunities for start-up, emerging, and existing Iowa firms.*	▪ **Create and Fund an Economic Development Director position on the Iowa Board of Regents** to provide catalytic support for regent university economic development initiatives.	Immediate
	▪ Develop and implement policies and procedures that actively **encourage faculty entrepreneurship and commercialization activities** at the regent universities.	Immediate
	▪ **Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.**	Immediate
	▪ Establish and fund a **University Entrepreneurs Center** at each university.	Short-term
	▪ **Form a statewide commercialization intermediary** for supporting, building, and sustaining development of new bioscience business enterprises in Iowa.	Immediate
Strategy Three: *Foster a business environment that supports, sustains, and encourages the growth and sustainability of bioscience firms in Iowa.*	▪ **Form the Iowa Bioscience Alliance** to facilitate communications, foster joint approaches to issues, and develop a critical mass of support to stimulate actions required to realize Iowa's bioscience vision.	Short-term
	▪ **Establish a State Bioscience Advocate** position, reporting to the Director of IDED, to drive the implementation of this strategy.	Short-term
	▪ **Implement Iowa's bioscience image and brand** through aggressive marketing, public relations, and signature events.	Immediate
	▪ **Review and make necessary changes to state incentives (including the Iowa Values Fund), tax policies, and legal code** to be responsive to the needs of growing bioscience firms.	Short-term
	▪ **Conduct an economic impact study** to measure the projected returns to the state and its regions that are estimated to result from proposed bioscience investments. The study should pay special attention to geographic equity and the diffusion of innovation benefits throughout the state.	Short-term
	▪ **Develop a training program for state and local economic development professionals** that would include information on university bioscience technology platforms and technical capabilities, the specialized needs of bioscience companies, and programs and incentives that can be used to assist new bioscience ventures and expanding and/or relocating firms.	Mid-term

Table 14: Iowa Bioscience Strategies and Actions (continued)

Strategy	Actions	Priority
Strategy Four: *Invest in and develop Iowa's bioscience talent pool.*	▪ **Improve K-12 scientific education** by focusing on stimulating interest among Iowa's children in science, thereby preparing them for careers in Iowa's growing bioscience sectors.	Mid-term
	▪ Develop a bioscience vocational career education program and **ensure seamless delivery between secondary and community college programs** that serve Iowa's growing concentration of bioscience employers.	Mid-term
	▪ **Streamline bioscience articulation agreements** within and between community colleges and Iowa's regent universities to allow students to transfer credits between academic institutions.	Short-term
	▪ **Leverage alumni associations and the state's Human Resources Recruitment Consortium** to attract to Iowa bioscience professionals, including experienced bioscience managers.	Immediate

STRATEGY ONE: BUILD IOWA'S BIOSCIENCE RESEARCH CAPACITY AROUND SELECTED TECHNOLOGY PLATFORMS FOCUSING ON INVESTMENTS IN TALENT, FACILITIES, AND EQUIPMENT.

World-class higher education and academic R&D infrastructure are absolute prerequisites for any state to become a world-class center for bioscience industry development. Strong research universities, comprising leading academicians and clinician-scientists in bioscience and biomedical fields, are the hallmark of successful bioscience states and regions. Generally, it is rare to have a cluster of bioscience firms without a correspondingly strong set of academic research institutions nearby.

A recent study by the U.S. Small Business Administration, the National Commission on Entrepreneurship, and the Kaufmann Center for Entrepreneurial Leadership concluded the following:

> *University expenditures on research and development promote higher new firm birth rates. The phenomenon is identical to that described by other researchers as "spillover" effect. Just like business firms, research universities form local innovative activity centers, from which knowledge spillovers and growth in specialized markets generate higher rates of new firm formation in one or more industries. The glue that holds these clusters together is the effort universities are putting into mechanisms to promote commercialization of the inventions that emerge from their laboratories.*[13]

As previously noted, Iowa has a significant base of academic R&D expertise in all "three legs of the bioscience stool"—plant, animal, and human biosciences. These strengths have already resulted in

[13] U.S. Small Business Administration, The National Commission on Entrepreneurship, and the Kaufmann Center for Entrepreneurial Leadership. *The Influence of R&D Expenditures on New Firm Formation and Economic Growth.* 2002, page 24.

bioscience economic development for Iowa, not only in terms of the attraction of significant R&D dollars into the state and the research employment that creates, but also in terms of new bioscience business ventures, value-added production from Iowa's biological commodities, and innovations for exploitation by Iowa's established base of bioscience-related corporations.

Iowa's regent universities have been active participants in economic development, including bioscience-based economic development:

- The University of Iowa Research Park on the Oakdale Campus contains 29 companies, employing approximately 1,500 individuals at an average salary of $50,000.[14] Capital investment in the park is approximately $120 million.
- The University of Northern Iowa's leading work in bio-based lubricants has resulted in new business formation in Iowa; and its Strategic Marketing Services program has provided research, planning, and feasibility services to more than 250 companies in Iowa and the Midwest.[15]
- Iowa State University, as the state's land grant institution, has a track record of being exceptionally proactive in applied agricultural R&D and the diffusion of its research knowledge and services through the ISU agriculture and manufacturing extension services. ISU's Research Park is home to 43 private and public firms, with the Research Park tenants responsible for significant economic impacts, including $76.3 million in total output, $29.5 million in labor income and almost 700 jobs.[16] In addition, on a typical annual basis, ISU assists more than 300 general business clients through its SBDC/Pappajohn Center. It also provides services to 40 prospective technology business start-ups on an annual basis and has upwards of 20 early-stage active technology clients at any given time.

Despite the historic and current efforts, there is significant opportunity to move these activities

Statistics on Assistance to Industry

Iowa State University

- In FY 2003 businesses (including commodity groups) funded 406 research projects at ISU totaling $14.9 million. In addition, businesses funded 55 nonresearch projects totaling $11.5 million.
- CIRAS provided technical assistance to approximately 170 companies (in many cases multiple times) during calendar year 2003.
- In FY 2003, IPRT provided short-term technical assistance to companies through 82 projects and assisted companies with 26 SBIR/STTR awards.
- SBDC/Pappajohn Center provided 6,000 hours of professional and student consulting assistance to start-up and existing companies and worked with 40 technology-based companies located at or affiliated with the ISU Research Park.
- It is estimated that about three inquiries from industry are handled each day through the Point of Contact system (in addition to non-company inquiries).

University of Iowa

- In FY 2003, businesses funded 371 research agreements at The University of Iowa. These generated $33.3 million in support. Over the past 5 years, 1,887 corporate research agreements generated $167.8 million in industrial research support. The FY 2003 total of $33.3 million represented 9.5 percent of the $352.3 million in total external support reported by the University during the year.
- The UI SBDC/PappaJohn Center provided more than 4,000 hours of consulting assistance to more than 400 clients, approximately 68% of which were start-ups. In addition, the Center provided services to 50 early-stage technology start-ups, offered 16 workshops, and handled approximately 10 inquiries per day.

[14] Source: University of Iowa.
[15] Source: University of Northern Iowa.
[16] Swenson, David. "The Economic Value of the ISU Research Park and its Tenants." Department of Economics, Iowa State University. February 2003.

further and accelerate the emergence of Iowa as a bioscience business leader. Doing so will require not only some changes, in particular streamlining and enhanced funding of commercialization and technology transfer operations at the universities, it also will require investments to reinforce and expand the universities' R&D capabilities in the core bioscience development platforms identified as keys to the development of a high-growth bioscience economy for Iowa.

The core competency evaluation identified six major platforms for short-term bioscience development in Iowa and four longer-term or niche opportunity areas as indicated in Table 15.

Table 15: Iowa's Bioscience Core Competency Platforms

Major Short-Term Platforms	Iowa State University	University of Iowa	University of Northern Iowa
BioEconomy	+++	+	++
Advanced Food and Feed	+++	+	
Animal Systems	+++	+	
Post-Genomic Medicine	+	+++	
Drug Discovery and Development	+	+++	
Biosecurity	++	+++	+
Niche or Longer-Term Platforms	**Iowa State University**	**University of Iowa**	**University of Northern Iowa**
Host-Parasite Biology and Systems	++	++	
Devices and Sensors (initial emphasis on lung imaging/biomedical imaging)	++	+++	+
Cardiovascular Research Institute	+	+++	
Free Radical Research Institute		+++	

Key: +++ *Lead or Primary Role* ++ *Important, Integral Role* + *Minor, Supporting Role*

Evident in Table 15 is the fact that all three of the regent universities have a role to play in the development and ongoing operations of the platforms. In the case of each platform, there is also a logical lead university taking a primary role in platform development.

Unfortunately, the current situation of state funding cuts in addition to increased competition from other states will make significant bioscience economic development growth stemming from university R&D more difficult. Universities do not have the resources to pursue the necessary actions with the vigor required for true success, and the substantial resources committed by competing states could siphon off Iowa's best and brightest who will be attracted by major recruitment packages and the promise of state-of-the-art research and laboratory facilities. Those faculty, students, and others interested in commercialization of their research innovations will be particularly vulnerable to out-of-state recruiting as competing states seek to attract those most likely to stimulate bioscience economic development.

As noted in the tactics outlined below, for Iowa to realize the opportunity that bioscience development presents, it must take action to reinforce and direct investment toward cementing its leadership position on the core bioscience platforms.

It is imperative, however, that the further development and enhancement of Iowa's bioscience platforms not be seen as a solution addressed only by reallocating existing university resources. The various states and regions with which Iowa will be competing for bioscience economic growth and development have been active in the infusion of new state funding and the proactive pursuit of federal research grants and infrastructural support. In addition, partnerships with industry and industry associations may form a supplementary route to enhanced funding streams for platform development.

Tactics

- Focus Iowa's bioscience efforts by targeting the further development of core bioscience platform areas—thereby accelerating Iowa's momentum and building upon its strength. Each platform cannot be pursued simultaneously, so priorities must be established.
- Focus the state's research infrastructure investments on supporting platform development and accelerating the movement of research innovations toward commercialization.
- Establish clear motivation and imperatives for university faculty, staff, and student engagement in translational work and the proactive commercialization of marketable research discoveries.
- Reinforce the R&D talent base through the strategic recruitment of Eminent Scholars and faculty entrepreneurs to key positions within each of the core platforms.
- Leverage Iowa's "three legs of the bioscience stool" strengths via increased cross-institutional collaborations—thereby maximizing expertise, resources, complementary competencies, and outside-the-box approaches across institutions.
- Build and expand the basic bioscience research base at the regent universities to ensure a strong long-term pipeline of discoveries feeding into translational and applied bioscience research.

Actions for Strategy One:

Action One: Undertake key recruitment, capacity building, and required investments to ensure rapid scientific progress in the core bioscience platforms.

Action Two: Create an Endowed Chairs Program to attract world-class, entrepreneurial talent in the core bioscience platforms.

Action Three: Form a Strategic Technology Platform Infrastructure Fund to strengthen and accelerate the scientific and commercialization work of the core bioscience platforms.

Action Four: Engage Iowa's Congressional Delegation in discussions pertaining to federal funding and specific project support.

Action Five: Institute an industry-university matching grant program dedicated to the identified bioscience technology platforms to encourage relationships between academic researchers and industry.

Action One: Undertake key recruitment, capacity building, and required investments to ensure rapid scientific progress in the core bioscience platforms.

Rationale: World-class science and innovation require world-class faculty and top-quality graduate students. The attraction and retention of high-quality scientists and researchers also depend on providing them with top-notch resources, staff, and support to pursue their research in an efficient and effective manner. While Battelle has identified the bioscience platforms that it perceives as presenting solid opportunities for bioscience development in the state, each of these platforms requires some reinforcing investments to help assure their status and rapid development progress.

Action Specifics: Each bioscience development platform presents unique opportunities for bioscience-based economic advancement in Iowa. While serving the overall vision and mission previously outlined, each platform may have its own vision, strengths to build upon, and needs to address. The following section outlines some of the specific opportunities and actions for each platform that might be addressed. However, it is important to recognize that the development of each platform will demand flexibility and

adjustments in order to ensure that opportunities are leveraged as they present themselves and that emerging areas are seized as the consortium evolves over time.

BioEconomy Platform—While Iowa already has substantial capabilities on both the production and R&D sides of the BioEconomy, cementing Iowa's leadership in the field will require further strategic investment and actions. Specific activities and needs might include the following:

- Creating the BioEconomy Academic Consortium, headquartered at Iowa State University, staffed with a full-time Director and two staff assistants ($300,000 annually).
- Providing $1 million in initial funding for a competitive matching grant program to be administered by the platform Executive Committee. As noted in the Phase I report, a moderate amount of annual research funding is likely to stimulate significant applied research returns at UNI. UNI has been particularly productive in bioeconomy-related research programs. Therefore, it is recommended that $300,000 of the $1 million be set aside for a competitive grant program at UNI.
- Investing in shared infrastructure and student training in biobased products and technology at ISU. Shared infrastructure will include dedicated space on the ISU campus for program offices and laboratories for bench-scale research in biobased products and expanded space and utilities for existing pilot-plant facilities. Infrastructure funds also will be used to purchase, install, and operate instrumentation required for a comprehensive platform in biorenewables research and development. Funds for student training will be used to provide industrial internships for graduate students and support faculty in developing and teaching courses in biorenewable resources. Estimates provided by ISU indicate a potential financial investment required of $8,625,000 over a 5-year time period.

Advanced Food and Feed Platform—Specific activities and needs might include the following:

- Creating the Advanced Food and Feed Academic Consortium, headquartered at Iowa State University, staffed with a full-time Director and two staff assistants ($300,000 annually).
- Enhancing ISU's existing strengths by hiring faculty with complementary skills, providing needed research instruments and equipment, and upgrading research facilities. Estimates provided by ISU indicate a potential financial investment required of $8,565,000 over a 5-year time period. The focus of the research and development activities will include
    - Discovery of substances in microorganisms, plants, and animals that have health-promoting or disease prevention effects in humans and livestock;
    - Proof of concept involving animal experiments and human clinical trials;
    - Product development involving plant and animal breeding or genetic engineering or more traditional food processing; and
    - Development of suitable processing technologies to deliver foods and ingredients having maximum health benefits.
- Investigating the opportunity to expand the academic side of the consortium into an Advanced Food and Feed Products Institute.
- Providing $500,000 in initial funding for a competitive matching grant program to be administered by the platform Executive Committee.
- Connecting ISU research labs to clinical labs and expertise at U of I.

- Expanding sensory expertise and associated facilities and linking them to U of I for toxicology and allergen analysis.
- Utilizing IDED's role in active work to recruit food processing companies and associated manufacturing firms to reinforce the comparatively small current base in Iowa.

Animal Systems Platform—Specific activities and needs might include the following:

- Creating the Animal Systems Academic Consortium, headquartered at Iowa State University, staffed with a full-time Director and two staff assistants. This could be expanded into an Animal Systems Institute along the lines of the Iowa State University Plant Sciences Institute ($300,000 annually).
- Providing $500,000 in initial funding for a competitive matching grant program to be administered by the platform Executive Committee.
- Creating an Animal Systems Institute at ISU to expand efforts of existing centers of excellence within the Consortium by providing start-up funding, graduate student training, and state-of-the-art equipment for advanced analysis in the areas of molecular biology, genomics, and proteomics to advance life sciences research and providing funds to support advanced genomic sequencing of animals and microbes to advance economic development and discovery. Estimates provided by ISU indicate a potential financial investment required of $6,250,000 over a 5-year time period.

Integrated Post-Genomic Medicine Platform—Specific activities and needs might include the following:

- Developing a comprehensive database for clinical phenotyping and retrieval of biological samples for deoxyribonucleic acid analysis. Development of such a database and retrieval system will give Iowa a major advantage in genomic medicine. Estimates provided by the University of Iowa indicate a potential financial investment required of $8,935,000 over a 5-year time period.
- Creating the Genomic Medicine Academic Consortium, headquartered at the University of Iowa, staffed with a full-time Director and two staff assistants ($300,000 annually).
- Providing $500,000 in initial funding for a competitive matching grant program to be administered by the platform Executive Committee.

Integrated Drug Discovery, Development, Piloting, and Production Platform—Specific activities and needs might include the following:

- Making near-term investment in resources and infrastructure to provide basic drug discovery services and a potential commercialization pathway for existing areas of research.
- Developing a larger-scale Drug Discovery Center catalyzing in-depth, bench-to-bedside drug opportunities.
- Developing and operating the Drug Discovery Center. U of I estimates that this will require $5,835,000 for the first 5 years. Additional resources required for pharmaceuticals and biologics development, outreach and marketing, quality control, medical direction of clinical trials and faculty with expertise in targeted drug delivery would total $4,660,000 over a 5-year period.
- Creating the Drug and Biologics Academic Consortium, headquartered at the University of Iowa, staffed with a full-time Director and two staff assistants. The Director is envisioned to hold the post of Director of Pharmaceuticals and Biologics Development.

- Providing $500,000 in initial funding for a competitive matching grant program to be administered by the platform Executive Committee.

Integrated Biosecurity Platform—Specific activities and needs might include the following:

- Creating the Integrated Biosecurity Academic Consortium, staffed with an initial full-time Co-Director headquartered at the University of Iowa and then supplemented by an additional Co-Director at Iowa State University. Each Co-Director will have two dedicated staff ($300,000 annually at each university). This could be built into an Institute for Integrated Biosecurity over time, with membership from U of I, ISU, UNI, the USDA Animal Health Research Laboratory and other Iowa parties. Within the Institute, research groups could be created to focus on
    - Infectious disease prevention, diagnostics, and treatment;
    - Monitoring, detection, and analytical devices;
    - Decontamination processes and equipment; and
    - Vaccine development and production.
- Providing $500,000 in initial funding for a competitive matching grant program to be administered by the platform Executive Committee.
- Creating, in the near term, a Center for Infectious Diseases, Therapeutics, Development and Evaluation at the University of Iowa with direct links to the Drug Discovery and Development Platform. Initial focus could be on respiratory diseases and pathogens. The U of I estimates a 5-year required budget for the Center at $8,425,000.

Biomedical Imaging Niche Platform: In light of the University of Iowa's significant recent success in securing funding and strong industry relationships in biomedical imaging, and given the importance of advanced biomedical imaging as a provider of new insights that lead to new biomedical discoveries, and the opportunity to work on imaging devices, algorithms, and software business opportunities, Battelle sees this as a short-term niche opportunity for development in Iowa. The following resources might be allocated to the biomedical imaging niche platform:

- $200,000 in annual funding to support a Platform Director at the University of Iowa, plus one assistant and associated operating cost.
- $300,000 in initial funds for a competitive matching grant program to be administered by the platform Executive Committee.

Resource Requirements:

The academic consortia will require funding. As noted above, each platform at the academic level will require a full-time Director and two support personnel to guide platform development activities and provide the direct links to the related industry groups and individual business partners. Each academic consortium should be allocated funding to cover these staff positions and associated operating costs. Funding for the platform consortium staffing should be allocated for 5 years. A review of platform performance should be performed after 5 years to assess further funding needs.

Platform	Academic Consortium Staffing	Competitive Matching Grant Program	Special Projects and Investments
BioEconomy	$300,000	$1,000,000	$1,725,000 per year for 5 years for shared infrastructure and training
Advanced Food and Feed	$300,000	$500,000	$1,713,000 per year for 5 years for shared infrastructure, key faculty, and staff scientists
Animal Systems	$300,000	$500,000	$1,250,000 per year for 5 years for shared infrastructure support, advanced sequencing projects, and advanced analysis in genomics and proteomics
Post-Genomic Medicine	$300,000	$500,000	$1,787,000 per year for 5 years – for Genomics/Phenotype Database and Retrieval System
Drug Discovery, Development, Piloting, and Production	Covered under special projects budget	$500,000	$1,167,000 per year for 5 years – for Drug Discovery Center's development and operation. $932,000 per year for 5 years – for staffing and platform reinforcement investments
Biosecurity	$300,000 each at two hubs ($600,000 total)	$500,000	$1,685,000 per year for 5 years – for Center for Infectious Diseases, Therapeutics, Development and Evaluation
Biomedical Imaging (Niche Platform)	$200,000	$300,000	

Time Frame: Short-term

Lead Organization(s): Iowa Board of Regents and the individual regent universities

Action Two: Create an Endowed Chairs Program to attract world-class, entrepreneurial talent in the core bioscience platforms.

Rationale: Numerous states, including Georgia, Missouri, Oklahoma, Florida, and South Carolina, have developed or are developing endowed chairs in an effort to develop world-class research excellence. Endowments are created by investing a donation that then provides ongoing income, with the recipient university deciding how much of the annual earnings will be spent on the

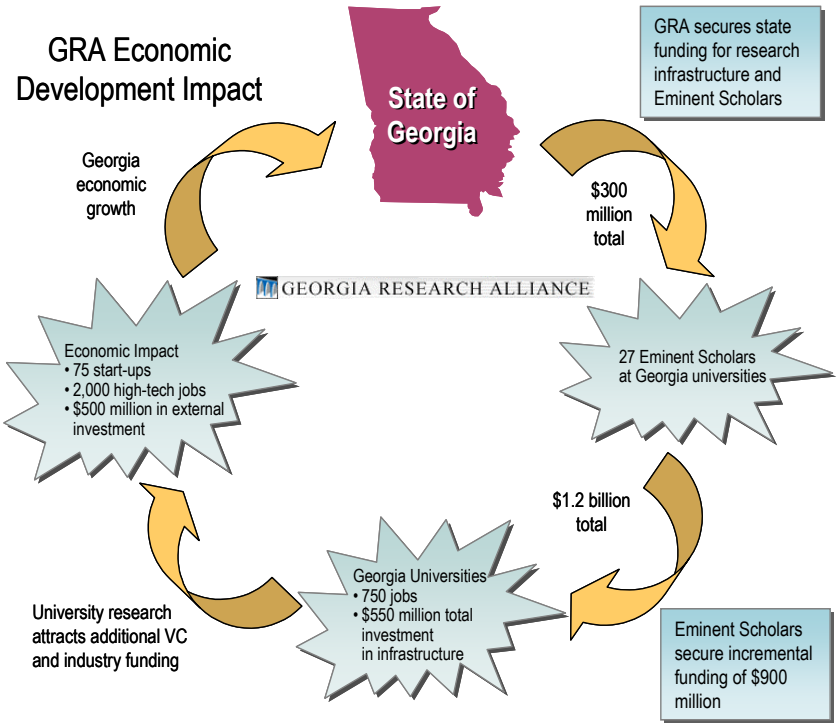
Examples of Endowed Chairs Programs

- **Missouri** will fund an endowed chairs program beginning in FY 2007 requiring both a nonstate commitment of a $2 million endowment or $100,000 per year for 20 years, and a university and state commitment of $100,000 per year for 20 years.
- **Oklahoma** and **Florida** are working on legislation to eliminate the backlog of state funding for endowed chairs. Oklahoma Governor Henry recently authorized a bond issue to match donations as part of his Economic Development Generating Excellence (EDGE) initiative. (Currently, $52 million in private donations is waiting for matching funds).
- In **South Carolina**, Clemson University will tap into state lottery funds set aside last year by the General Assembly for an endowed chairs program. BMW Manufacturing Corp. pledged $10 million, with another $5 million to be raised by suppliers, for the state to match. Clemson will use the funds to recruit engineers and scientists to the school's new graduate program in automotive systems integration.

faculty member. The general consensus is that it takes an endowment of about $3 million to support a top researcher. What is also agreed upon is that endowed chairs represent an important tool in building a research hub capable of attracting large federal grants, commercializing technology, and spawning start-up companies.

The experience of the Georgia Research Alliance (GRA) with entrepreneurial endowed chairs points to the success such appointments can promote (Figure 12). The Eminent Scholars Program is a central component of the GRA strategy, which, over its 10 years of operation, has attracted 32 scholars. The grants are aimed at entrepreneurial professors. A large percentage of the endowed chairs actually bring with them an existing company or relocate with the interest of commercializing their research. In all, GRA has linked more than a dozen start-up companies to the Eminent Scholars Program and estimates that about $800 million in federal and private funding has been captured by Georgia as a result of the program. GRA, which helps allocate $30 million to $35 million a year in state funding, provides $750,000 to establish each Eminent Scholar chair. That amount has to be matched by the host institution. In addition, GRA provides funding to build and renovate labs or to outfit them with sophisticated equipment.

Figure 12: Georgia Research Alliance Model



In taking a similar approach, Iowa can help strengthen key bioscience research platforms—working to attract senior Eminent Scholars in the platform fields who have existing entrepreneurial experience and may actually relocate companies with them.

Action Specifics: An entrepreneurial endowed chair position should be established within each of the six main platforms over several years. In addition, it is recommended that an endowed entrepreneurial chair be established at the University of Iowa College of Medicine in biomedical imaging to help cement and

build upon recent major advances in advanced lung imaging. Thus, a total of seven endowed entrepreneurial chairs are recommended, distributed as shown in Table 16.

Table 16: Proposed Bioscience Endowed Chairs

Major Short-Term Platforms	Iowa State University	University of Iowa	University of Northern Iowa
BioEconomy	EE Chair		
Advanced Food and Feed	EE Chair		
Animal Systems	EE Chair		
Post-Genomic Medicine		EE Chair	
Drug Discovery and Development		EE Chair	
Biosecurity		EE Chair	
Niche Platform	**Iowa State University**	**University of Iowa**	**University of Northern Iowa**
Biomedical Imaging		EE Chair	

It is recommended that, in each case, the endowment be used to attract a scholar and associated team members, recruited nationally and internationally, who could bring with them a related start-up business venture or a concept for near-term commercialization.

Resource Requirements: Each of the seven endowed chair positions will require an endowment of $3 million, for a total combined endowment requirement of $21 million. It is recommended that the State of Iowa provide one-third of the endowments ($7 million) in direct funding, with a requirement that recipient universities seek private donations for the remaining two-thirds ($14 million). Private donors, industry, and trade groups related to each platform within Iowa will be likely sources of supporting funds.

These chairs should be funded in accordance with the technology platform priorities. In other words, those platforms with the highest priority should receive funding for an Eminent Scholar first. It is anticipated that Eminent Scholars for two platforms could be funded per year, so that within 4 years all the platforms' Eminent Scholars could be funded.

Time Frame: Short-term

Lead Organization(s): Iowa Board of Regents and the individual regent universities

Action Three: Form a Strategic Technology Platform Infrastructure Fund to strengthen and accelerate the scientific and commercialization work of the core bioscience platforms.

Rationale: As noted previously, bioscience-based economic development holds great potential for Iowa; but, the state is in competition with other states that are making considerable investments in building their bioscience technology base. California, for example, is investing $100 million in a bioengineering and biotechnology institute, while much of Georgia's $300 million spent over 10 years has gone to support the development of core research facilities. Texas appropriated $800 million for seven new or expanded health science research centers. Attracting and retaining world-class bioscience R&D talent in Iowa require world-class facilities, infrastructure, and scientific resources.

Action Specifics: Iowa faces two primary issues in both enhancing and building more robust technology platforms:

- The need for facilities and equipment for each platform area
- The need for technology infrastructure investments in pilot plants, demonstration facilities, and other translational facilities and equipment that enable the platforms to move research downstream so that it is more market ready for industry use and adaptation.

The proposed Strategic Technology Platform Infrastructure Fund will serve as a vehicle to make strategic state investments in key areas that serve to build both research stature and technology commercialization capabilities. As a result of the Iowa Values Fund, nearly $30 million in investments are being made to address facilities and commercialization; however, additional investments are still needed for facilities, equipment, technology infrastructure related to technology platforms.

It is suggested that the Strategic Technology Platform Infrastructure Fund have two components:

- A matching grant program to catalyze key investments required to strengthen and accelerate the scientific and commercialization work of the core bioscience platforms
- A one-time investment fund for other specialized infrastructure needs (such as wet labs, incubator space, specialized equipment, etc.) related to one or more platforms.

It is recommended that the Iowa Values Fund administer and manage this fund since it is consistent with its current efforts and its Board represents a partnership of several state agencies, including the IDED and Board of Regents.

Examples of States' Investments in the Biosciences

- California is investing $100 million in a bioengineering and biotechnology institute and $500 million in pension funds toward the California Biotechnology Program
- Georgia has invested more than $300 million over a 10-year period to build core research facilities and to attract Eminent Scholars, the majority of whom are in the life sciences. It has created a $1 billion Georgia Cancer Coalition that is designed to make Georgia a national leader in cancer prevention, treatment, and research
- Texas appropriated $800 million for seven new or expanded health science research centers.
- In 2002, Arizona's public and private leaders raised $90 million to support the development of the Translational Genomics Research Institute (TGen), a nonprofit biomedical research institute whose mission is to make and translate genomic discoveries into advances in human health. In 2003, the Legislature and Governor approved $440 million to fund university research facilities, primarily in the biosciences.
- The State of Florida committed $310 million in one-time federal economic-stimulus funds and nearly $200 million more in county and local resources to recruit the Scripps Institute to locate an East Coast facility on a 2,000-acre site in West Palm Beach. The state has also provided $30 million to create three Centers of Excellence, two of which are in the biosciences, and recently announced that it would invest up to $1 billion of its $102 billion employee pension fund in venture capital. An initial $350 million will be invested during the next 12 months.
- Anticipating more than $500 million in increased tax revenue over the next decade from growth of the bioscience sector, Kansas passed an Economic Growth Act that authorizes creation of a Kansas Bioscience Authority with the capacity to provide funding for faculty recruitment, research collaboration, and additional facilities.

Guidelines will need to be established for this two-element fund once initial financing is provided. The state should not use a rigid time frame for awarding funds, but instead should establish criteria that will drive the utilization of the fund based on appropriate measures, such as economic impact, linkages to one or more platforms, etc.

Resource Requirements: Using the benefit of low-interest rates, bond financing is an obvious route to generate the investment dollars required to support major capital and infrastructure investments in the core bioscience platforms. Consideration should be given to using some of the state's bonding capacity to move from a "pay-as-you-go" philosophy to an investment philosophy, particularly for what may emerge as major strategic projects whose price tags would be too large in any one year for the state to make investments. By enabling general fund bond financing of the fund at approximately $170 million, or $97 million in the first 5 years and $73 million in the second 5 years, actual investments can be made over several years, enabling the state to make strategic investments as opportunities arise. These are indeed investments in Iowa's economic future.

Time Frame: Short-term

Lead Organization(s): Iowa Values Fund, which includes staff support provided by the IDED and the Iowa Board of Regents

Action Four: Engage Iowa's Congressional Delegation in discussions pertaining to federal funding and specific project support.

Rationale: Historically, federal R&D support has played a very important, if often unheralded, role in building up the core competencies of leading technology regions. The importance of discretionary R&D support in building Silicon Valley and the Route 128 corridor in Massachusetts has been well documented. The recent rise of northern Virginia as a leading Internet region and the rise of Maryland as a center for the biosciences also reflect years of strong federal discretionary R&D support.

Today, many states, through their public and private representatives, have been working more closely with their Congressional Delegations to ensure federal investments that help create the research and research infrastructure anchors that help build bioscience economies. As noted under "Key Success Factors," one key lesson for states and regions building a bioscience economy is the importance of federal funds for federally designated centers and institutes, whether the funding comes in the form of operating or capital funds. Almost every major mature bioscience region or state in the nation has one or more federal "anchors" that have contributed to building its bioscience base, e.g., the National Institute of Environmental Health Sciences in Research Triangle Park, Lincoln and Draper Labs in Boston, and NIH in Maryland. Discretionary federal funding unfettered by federal mission also plays a role in enabling exploratory research to be undertaken that may lead, many years later, to applications in the health and biomedical arenas.

Increasingly, states, ranging from Missouri and Pennsylvania to Ohio and Connecticut, are seeing the benefits from such federal investments. Missouri's efforts in working with its Congressional Delegation have brought in $25 million a year for the past several years. This funding is helping to build the University of Missouri System's research infrastructure, which has been adversely affected by a shortage of state capital funds. Research infrastructure funding is generally not available from federal grant programs, necessitating efforts to identify and secure discretionary federal funding support.

Action Specifics: Iowa needs to identify key areas where the state can compete successfully for federal discretionary funding. Iowa should work closely with its Congressional Delegation to ensure that the state and its research institutions are given strong consideration and viewed as a key region for bioscience research funding. It is suggested that Iowa's research universities, state government, and industry leadership identify annually those parts of this bioscience strategy that could benefit from federal funding and investment. This multiyear strategy provides the basis for identifying an annual Iowa Congressional Delegation agenda to secure discretionary federal infrastructure and research funding support. Federal

legislators need to be presented with specific projects for which they may work to secure funding. When equipped with a specific project "ask," Congressional Representatives and Senators are far more likely to be able to take the actions required to apply leverage to funding agencies or introduce financing bills.

Resource Requirements: No new resources will be required for this action; rather, this function needs to be lodged in some organization and actively undertaken and updated.

Time Frame: Short-term

Lead Organization(s): IDED and the Iowa Board of Regents

Action Five: Institute an industry-university matching grant program dedicated to the identified bioscience technology platforms to encourage relationships between academic researchers and industry.

Rationale: To build a strong, nationally competitive, research enterprise, research universities and organizations are increasingly partnering with local, regional, and national firms. While Iowa does not yet have a critical mass of bioscience firms in each of the platform areas, there are representative companies in each of the platforms that may form the foundation for enhanced industry-university relationships. Finding ways to link the needs of firms and the expertise of bioscience faculty and to undertake collaborative research, translational research, and applications can benefit faculty interested in seeing their ideas developed. For the state and its citizens, this represents a way for higher education institutions to be accessible and beneficial to industry. Numerous states have initiated matching grant programs and other seeding efforts to promote active industry-university joint research relationships. Examples include the following:

- The Kentucky Research Voucher program
- Utah Centers of Excellence program
- Pennsylvania Ben Franklin program
- California's Regional Technology Alliance program.

Utah's program, for example, is budgeted at approximately $2 million per year, supporting approximately 15 projects at any given time, with allocations up to a maximum of $200,000 per project. The state funding must be matched by industrial partners. Since 1986, a total of 80 projects have been funded at a cumulative investment of $832 million, matched 10:1 by funds from industrial partners.

Action Specifics: To assist Iowa's existing bioscience base, encourage industry-university collaborations, and spur new enterprise development, a Bioscience Matching Challenge Grant Program is proposed. Funds would be awarded on a competitive basis with a 3:1 industry match required, including at least a 1:1 cash match. Funding would total at least $100,000 to $250,000 per year, with maximum awards limited to 3 years. This level of funding can provide the scale of impact required to spur high-level, collaborative research. University intellectual property policies would apply; however, the industry participant would have a "first right of refusal" for an exclusive licensing option for a funded project.

Resource Requirements: Total state funding through bond financing would begin at $1.5 million to $3 million in the first year and ramp up to $3 million by year 5 and then to $5 million by year 10. The program should focus on the biosciences for the first few years but be expanded to IT and advanced manufacturing in future years.

Time Frame: Immediately

Lead Organization(s): IDED

STRATEGY TWO: ENCOURAGE AND FACILITATE THE COMMERCIALIZATION OF BIOSCIENCE R&D TO ENHANCE OPPORTUNITIES FOR START-UP, EMERGING, AND EXISTING IOWA FIRMS.

To accomplish sustainable economic development, the state also must focus significant efforts on converting research innovations into commercial business enterprises. The path from innovation at the bench to a successful company deploying the innovation in the marketplace is complex, and Iowa's investments need to be properly aligned in order to ensure success at each major factor in the path to commercialization.

Historically, Iowa is not among the most dynamic of states when it comes to entrepreneurship and new business development. The Progressive Policy Institute's *2002 State New Economy Index* ranks Iowa in the bottom quartile of states for "economic dynamism," a metric defining a state's ability to foster the creation of new firms, support firms that innovate, and cultivate a culture that is epitomized by fast-growing, entrepreneurial companies. The Progressive Policy Institute found Iowa to rank 37th in the nation in the number of scientists and engineers in the workforce, 32nd in industry investment in R&D, 42nd in venture capital, and 32nd in innovation capacity[17]—so there is certainly a need to upgrade the state's performance in the innovation-driven economy.

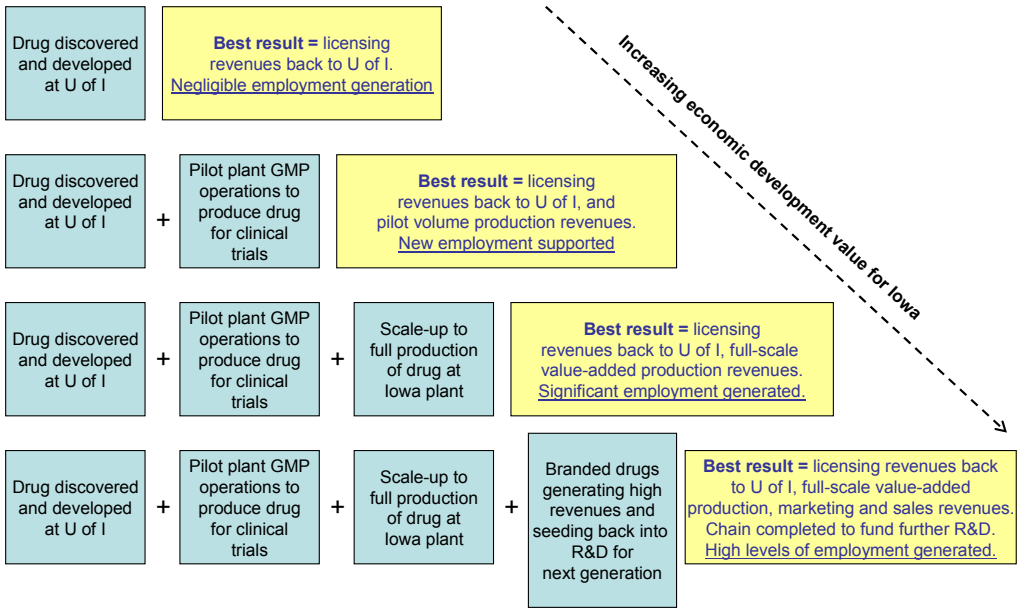
Economic payoffs from investing in the commercialization of the biosciences can be significant. One study found that 31 percent of new products and 11 percent of new processes in the biomedical field could not have developed without substantial delay had there not been academic research.[18] However, research by itself does not generate substantive economic development results. What has to happen to engender economic development is the conversion of research discoveries into marketable products and services, providing jobs, income, and revenues through a value-added output chain. Figure 13 illustrates one example of the economic value chain that indicates the conceptual benefits that result from commercialization and value-adding activities.

Technology commercialization and the building of economic value chains involve bridging the gap between innovations and discoveries and the commercial development of those discoveries by bioscience businesses. There are three macro-level components that a state must adequately address to achieve commercialization success:

- The technology transfer functions, including policies, structure, incentives, and approach. Cutting-edge programs actively encourage faculty and student engagement in commercialization initiatives and aggressively pursue faculty disclosures, patenting, and licensing. New business enterprise formations are actively encouraged where justified, as well as the active marketing of university IP to existing business enterprises. In leading universities, such functions are also being expanded to include active technology commercialization.

[17] http://neweconomyindex.org/states/2002/iowa.html.
[18] Edwin Mansfield, "Academic Research and Industrial Innovation", *Research Policy*, 1998, 26:773-776

Figure 13: Multiple Stages of Value Capture from Innovation through Production



Source: Battelle Technology Partnership Practice

- Commercialization activities, including assessing the market and commercial viability of intellectual property, finding funding support to assess the value of research discoveries, developing a commercialization plan, and funding proof-of-concept/reduction-to-practice development. Purdue University, for example, has structured funding mechanisms to support this.
- Firm start-up support, whereby the technology transfer and commercialization functions are broadened to provide searches for seed capital, management talent, and marketing assistance. Some universities have created third-party intermediaries to play this role (examples include Baylor, the Mayo Clinic, and Carnegie Mellon University), and some communities have formed stand-alone organizations such as the St. Louis BioGenerator and the Oklahoma Technology Commercialization Center.

Purdue University's Gateways Program

Purdue University's Gateways Program assists Purdue University researchers and other Indiana entrepreneurs in the commercialization of intellectual property. The program provides a range of services including business plan development, test marketing, and financial and technical advice. The Gateways Program uses a methodology that is often employed by high-performing firms in growing industries to identify, evaluate, and assist commercial business opportunities. Their "stage-gate" process includes matching clients with market-specific mentors, helping clients identify a clear pathway to development, developing early-stage gap financing resources, and assisting with the formation of a management team.

Within Iowa, the commercialization pathway needs to begin with a consistent message from both state and university leadership, that active faculty engagement in discovery disclosures and commercialization is encouraged. In a recent study published by the Southern Growth Policies Board,[19] it was discovered that a common theme among best-practice universities in commercialization and economic development

[19] Tornatzky, Louis, Paul Waugaman, and Denis O. Gray. "Innovation U.: New University Roles in a Knowledge Economy." Southern Growth Policies Board, 2002.

is a highly engaged senior university leadership team that is actively pursuing commercialization as a major university agenda. The authors of this study note the following:

> *Government leaders that have an interest in steering their state-based public institutions toward greater partnering need to be mindful of the leadership issue and how important it is to make careful choices at this level. University CEOs and other senior leaders will typically be in their jobs five to 10 years. If they are hostile, inexperienced, or immune to this agenda, nothing much will happen during their watch.*

Other factors found to be of substantial importance at best-practice universities in the Southern Growth Policies Board study include the following:

Baylor's BCM Technologies

BCM Technologies (BCMT), a wholly owned subsidiary of Baylor College of Medicine (BCM), was established in 1983 to help commercialize technology generated by the college. BCMT helps BCM's licensing office decide whether a given BCM invention is better commercialized by a license or by formation of a spin-off company. In the latter case, it catalyzes formation of a locally based company through a pre-seed investment and provision of interim management services. BCMT staff draft the preliminary business plan for the company, structure the company's initial ownership including any shares granted to BCM in consideration of IP rights, serve as directors and interim executive management, and pitch the first-stage investment deal. BCMT also helps recruit the spin-offs first management team and structures a first formal round of investment in which the College endowment and outsiders may participate. In the past 10 years, 16 BCMT spin-outs have raised more than $300 million in capital from 30 different investment groups. BCMT claims a 40 percent "internal rate of return" on its investment portfolio and has returned substantial cash to BCM.

- Targeted recruitment of administrators and faculty experienced in university technology commercialization and corporate partnerships
- Policies and reward structures to incentivize faculty engagement in commercialization and industry partnerships
- An established and celebrated local lore regarding successful faculty entrepreneurs, important job creation initiatives, and projects that significantly helped local industry
- Commercialization and partnering institutionalized for the long-term within the university, and a deep pool of staff dedicated to realizing the vision
- An aligned set of university rules and regulations that serve to favor commercialization, entrepreneurship, and corporate partnering
- Customer-friendly policies and contact points to facilitate relationships with the private sector
- Efficient and well-funded technology transfer enterprises
- Active assistance and outreach to existing industry and businesses
- Entrepreneurial development services, including incubation facilities, entrepreneurship education, research parks with space for spin-off and corporate partners, outreach programs to engage community entrepreneurs, and well-formed relationships with venture financing sources
- Placement and career services working to place students at in-state employers and establish early relationships via internships
- Active university involvement in state and local economic development agencies

- Participation in joint advisory boards and councils with the private sector to help align research and assistance programs with the needs of industry.

While the regent universities have an important role to play in the path to commercialization, the burden of such activity must not be seen as theirs alone. Economic development in Iowa should be a priority for all in the state—legislators, administrators, community leaders, business leaders, educators, and the general citizenry. This broader support for entrepreneurship and commercialization needs to be anchored in a state-supported commercialization agency separate from, but working collaboratively with, the university system. Numerous successful examples of such commercialization agencies exist throughout the United States, with components of their missions usually containing some or all of the following:

Oklahoma Technology Commercialization Center (OTCC)

OTCC plays an important, and generally neglected, role in Oklahoma by positioning Oklahoma entrepreneurs to grow viable businesses. One key way is by helping start-ups focus their business plans and strategies through hands-on educational and training support and detailed consulting. OTCC also helps entrepreneurs secure angel financing and other early-stage funding (including a state seed fund program that it operates). OTCC has helped organize 44 angel investor groups across Oklahoma, involving 300 investors with a net worth of $2 billion.

In addition, OTCC has established a certified Service Provider Program, which identifies proven, quality service providers (representing intellectual property law, corporate law, business consultants, marketing, engineering, science, and financial consulting), who are interested in providing assistance and support to technology entrepreneurs.

The most important contribution of OTCC is its activities in helping to stimulate investment deal flow, as well as improving the quality of deal flow to private investors. In its first 2 years of operation, OTCC served 467 clients, of which 268 have received detailed project assistance and 74 have been presented before angel investor and other financing sources with nearly $15 million in hard-to-find pre-seed and seed capital dollars raised, leveraging more than four times the amount of state investment in OTCC operations.

- Assistance provided directly by experienced successful serial entrepreneurs for business plan development, market assessments, technology assessments, and other planning activities
- Operation of competitive seed and prototype development funds
- Access to competitive seed and early-stage financing funding, usually via administration of state-funded venture financing pools
- Close linkages to private angel investors and the venture capital community
- Access to an experienced pool of managers and operations talent who can staff, mentor, or advise start-up enterprises
- Coordination of, and access to, entrepreneurial and business skill development courses
- Operation of a proof-of-concept/prototype development fund
- Support and advice for accessing SBIR/STTR funds and other sources of early-stage financing.

Placing these activities within a stand-alone, state-supported intermediary organization has several advantages. It allows for the hiring of managers, personnel, and support staff who are dedicated to, and experienced in, start-up assistance and entrepreneurship. It provides a clear partner organization for universities and other technology commercialization engines, ensuring that the burden of state technology commercialization not fall on them alone. It provides private venture funders with a source of business

funding opportunities that have been through a proven and professional process of advice, assistance, and due diligence—helping to lower investment risk. Finally, such an organization can hire and pay the experienced serial entrepreneurial managers that make this work; with their salaries covered in part by their administration of a pre-seed fund for biosciences, operation of a prototype development fund, and ongoing coaching and mentoring to start-ups. An additional task of this organization is to recruit such professionals to manage these functions with the intent to locate and place them into senior positions with start-ups within 18 months after being recruited to this intermediary, helping to build a talent capacity in Iowa.

Clearly then, bioscience technology commercialization in Iowa needs to be accomplished through a series of initiatives with no single organization responsible for the entire effort:

- The regent universities have a strong responsibility to mine their R&D to identify commercialization opportunities and assist in the early-stage development of those technologies most promising for commercial success. Through efficient technology transfer, new business support services, entrepreneurial education, and business incubation initiatives, the regent universities will be a key driver of early-stage bioscience venture formation, in addition to encouraging R&D partnerships with Iowa bioscience industry.
- State government has an important role to play in providing a reliable, long-term funding stream to support the above university activities, but also must be proactively engaged in the organization and funding of a stand-alone technology commercialization intermediary organization ensuring that non-university–based entrepreneurs have a contact point for assistance and that university-birthed start-ups have the professional advice, assistance, and access to funding that is required to move them to the next level of growth. Successful bioscience economic development is also facilitated by the establishment of formal and informal networks of experienced company leaders, entrepreneurs, and professional advisors able to mentor one another, provide a unified voice on policies and issues of importance to their industry, and have a strong place at the table for influencing R&D and other related bioscience support directions for the state.

Tactics

The following key tactics will help position Iowa to accomplish this strategy:

- Optimally leveraging academic R&D, intellectual resources, and scientific infrastructure to realize business growth and wealth creation in the State of Iowa from its regent universities
- Providing long-term financial support to both academe and a stand-alone commercialization intermediary organization to provide consistent guidance and support to entrepreneurial endeavors from conception to accessing major venture capital rounds and other expansion capital resources
- Addressing the need for networking opportunities for would-be and experienced entrepreneurs and technology commercialization personnel.

Actions for Strategy Two:

Action One: Create an Economic Development Director position at the Iowa Board of Regents to provide catalytic support for regent university economic development initiatives.

Action Two: Develop and implement policies and procedures that actively encourage faculty entrepreneurship and commercialization activities at the regent universities.

Action Three: Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.

Action Four: Establish and fund a University Entrepreneurs Center at each university.

Action Five: Form a statewide commercialization intermediary for supporting, building, and sustaining new bioscience business enterprise development in Iowa.

Action One: Create and fund an Economic Development Director position on the Iowa Board of Regents to provide catalytic support for regent university economic development initiatives.

Rationale: Iowa's bioscience R&D base largely resides within the regent universities. As such, it is imperative that the regent universities be brought into alignment in terms of the provision and support of economic development, corporate partnering, technology commercialization, and faculty entrepreneurship. Currently, there are distinct differences between the resources, capabilities, and impetus for economic development action across the universities. Iowa State University's history as a land grant institution brings with it a culture of outreach, industry collaboration, and technology transfer. The more traditional academic structure of the University of Iowa, on the other hand, has placed a lesser emphasis on such activity. By appointing an economic development director as a senior staff member of the Board of Regents, the Regents will be able to support and encourage efforts to make the technology platforms more robust; help address barriers and impediments to technology transfer, commercialization, and industry partnering; and otherwise play a catalytic role with each university. In addition, this position can serve as staff support to the newly created, industry-driven, economic development committee that has been formed by the Regents to pursue similar initiatives. Providing direct support for this committee will help ensure that the guidance provided regarding new initiatives and revised policies and procedures is implemented.

Yale University's Office of Cooperative Research

Yale University's Office of Cooperative Research highlights the following reasons for universities to be involved in start-ups:

- Public Benefit and Academic Mission. The generation of widely applicable public benefits from research discoveries made at the university is consistent with the academic mission and goals of the faculty of all major institutions.
- Economic Development. New ventures formed to undertake the commercialization of inventions provide opportunities to promote the development of the local economy.
- Faculty Recruitment and Retention. It has become more common for faculty members being recruited to the university to inquire about opportunities to become involved with existing as well as start-up companies in the area. It is also increasingly common for faculty spouses to look for private sector companies for employment.
- Financial Incentives. Universities will accept equity as part of the consideration for licensing intellectual property or assisting in the formation of a new venture.

Action Specifics: This position on the Board of Regents will need to be staffed by a person with several key characteristics: (1) experience in collaborations between industry and academe, (2) credibility within the academic community, and (3) understanding of the basic requirements of moving technology from the bench to the marketplace. A person with a background in academe, but with significant industry and business development experience, would be ideal.

The Regent Economic Development Director would be responsible for aligning the regent universities in Iowa on delivery of the core actions outlined for them within this bioscience strategy. The Director would work to ensure that economic development and commercialization are maintained as high-priority activities at each of the regent universities and that the Regents provide sufficient leverage with the state to help ensure that these important activities are adequately funded. The Director will staff the newly created, industry-driven, economic development committee and work to carry out its directives. In addition, the position also will coordinate with the proposed Bioscience Advocate within IDED (Strategy Three, Action Two) regarding proposed initiatives, policies, procedures, and university reporting requirements and information collection. In neither case is the intent to use these positions to create more administrative reporting; the clear intent of both positions is to create catalysts for action working with higher education, industry, and others.

Resource Requirements: $150,000 per year including support costs for the first 5 years

Time Frame: Immediate

Lead Organization(s): Iowa Board of Regents

Action Two: Develop and implement policies and procedures that actively encourage faculty entrepreneurship and commercialization activities at the regent universities.

Rationale: For Iowa to succeed as a center for bioscience sector growth, its R&D-generating institutions must be places that celebrate and facilitate the movement of discovery to commercialization. Doing so requires that many issues be addressed, including faculty incentives; conflict-of-interest policies; access to commercialization space; and provision of advice and professional assistance, technology transfer, and incubation services. University faculty has the responsibility to pursue scholarship and to educate the next generation of scholars and practitioners. In addition, in an academic medical center or veterinary college setting, there is the added mission of clinical practice. As such, there are considerable requirements placed on the time and energy of faculty; it is, therefore, imperative that the pathway to commercialization of their innovations be seen as well-supported and "doable." Those states and regions of the country that are performing well as technology growth poles tend to share a factor in common—they are home to universities that have embraced the commercialization mission and put in place policies, procedures, and proactive services to facilitate it.

Action Specifics: One of the characteristics of best-practice universities in technology development and commercialization is that they have established a culture and policies that provide clear rewards and incentives for faculty engagement in commercialization, translational research, and industry collaborations. Such support has to be expressed vigorously from the highest levels of university administration**,** with a clear message sent to deans and department heads that technology commercialization is viewed equal in importance to research and education missions.

Actions taken in relation to university procedures and policies must be seen by the faculty to be supportive of entrepreneurial and commercialization activities. This requires that the university's administration is seen as being "on the entrepreneurial faculty members' side," working with them to find ways to make necessary actions happen. Being flexible in the provision of entrepreneurial leave, allowing very early-stage tech commercialization efforts to occur within faculty members' on-campus labs, and actively celebrating faculty commercialization efforts in university communications are the types of activity required.

University administration also can be directly supportive of faculty entrepreneurship by funding "entrepreneurial fellows," positions in which active university financial support is provided to scholars with highly promising technology commercialization opportunities. Such fellowships also can be a means to retain highly promising postdocs and graduate students at the universities to assist in commercialization of their R&D work.

Therefore, specific actions that the Iowa Board of Regents and the individual regent universities should pursue include the following:

- Providing clear rewards and incentives for faculty engagement in commercialization of innovation with translational research, and ensuring technology commercialization is viewed equal in importance to research and education missions
- Being flexible in allowing the very earliest investigations of commercialization and business start-up to occur within faculty labs
- Providing flexible entrepreneurial leave policies
- Funding "entrepreneurial fellows" positions, providing university support to those engaged in entrepreneurial R&D.

Resource Requirements: $200,000 per year for the first 5 years, including fellows and support costs to address various elements listed above

Time Frame: Immediate

Lead Organization(s): Iowa Board of Regents and the individual regent universities. Potential requirement for state legislation and policy changes.

Action Three: Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.

Rationale: As the 21st century progresses, it is clear that knowledge and innovation are going to be the drivers of economic progress. As such, those institutions that generate knowledge and innovation have to be equipped with the resources required to maximize their positive economic output. Against this background, it is imperative that the State of Iowa make commercialization and industry partnering not only a core mission of its universities, but also one that is well funded and supported by the state.

Wisconsin Alumni Research Foundation (WARF)

Established in 1925, WARF's mission is to support scientific research at UW by moving inventions to the marketplace and investing licensing proceeds to fund further research. It has been highly successful, and each year more than $1 billion of products are sold under license from the organization. WARF receives 360 disclosures annually and accepts 60 percent for patent applications. WARF licenses 100 to120 technologies per year and returns $40 million to $45 million back to the university. More than 300 UW faculty and researchers are currently receiving WARF patent royalties.

WARF's influence extends beyond the Madison campus as the organization also manages the WISys Technology Foundation, which provides patent and licensing services to the entire UW System. WISys, established in 2000 as a pilot project, is a wholly owned subsidiary of WARF. The foundation is currently handling disclosures for 12 of Wisconsin's 13 four-year universities, and their portfolio includes some exciting technologies from campuses in Milwaukee to Eau Claire.

WARF's "What's IN It For Wisconsin Business" campaign is designed to make the Madison-based foundation more accessible to companies throughout the state, as well as to educate them about the wealth of home-grown product potential—in the form of patented UW discoveries. Since 1993, WARF also has taken an equity position in 29 start-ups, many of them in Wisconsin.

Unfunded mandates to the universities, at a point in time when faculty salaries and other basics are essentially frozen, will be ineffectual. Iowa cannot afford to lose the opportunity it has to assume a leadership position in key areas of the bioscience economy. Instead, it must invest in its bioscience technology and innovation drivers.

Action Specifics: Each of the platforms will require investment and support in university-based commercialization and technology transfer, with specific services provided in the following areas:

- **Proactive mining of university R&D for commercialization opportunities** (e.g., proof-of-concept/prototype development support). The current situation facing Iowa's universities—limited staff and, depending on the institution, differing policy support for technology transfer and commercialization—leads to a less-than-optimal effort to encourage faculty disclosure and entrepreneurial activity, including licensing and commercialization. This situation runs the risk of missing opportunities among faculty who are not entrepreneurially or commercially inclined. Instead, the universities should have staff experienced in recognizing innovations with commercial market opportunity and who are actively mining departments and research programs. Each of the platforms will be established to directly facilitate commercialization, so this will be an integral function of each platform. However, many opportunities also will exist at the universities outside of the direct platform areas, so at least one full-time employee (FTE) will be required at both ISU and U of I, plus a half-FTE at UNI.
- **Technology transfer and IP protection**. Efficient technology transfer and IP protection operations, operating at a realistic commercial pace, are critical. If these functions create significant bottlenecks and long delays in the commercialization process, then faculty may be dissuaded from commercialization endeavors, market opportunities may be lost, and industry partners frustrated. U of I needs additional resources to build its capabilities in this area to the same level as that enjoyed at ISU.
- **Preliminary technical and business development assistance** to emerging faculty entrepreneurs and basic business plan development and application assistance for accessing the services and resources of the statewide commercialization intermediary organization. Certain services are best delivered at the local, university-level, whereas others will be more efficiently provided through a statewide commercialization intermediary organization. At the university level, staff will be required for very early-stage business development services to coordinate access to outside expertise and align services with the statewide commercialization intermediary.

  Ultimately, both ISU and U of I should be staffed with two FTEs to provide preliminary business development assistance (one bio-related and one for other opportunity areas). UNI should have one FTE in a similar position. Based on ISU-provided norms, funding for these positions will approximate $150,000 per FTE for salary, operating costs, and administrative support (a total of $750,000 for the five positions across the three universities). ISU and U of I should each be allocated $250,000 per year to acquire services of outside experts in assisting very early-stage inquiries, while UNI should receive $100,000.
- **Maintenance, operation, and expansion of incubator facilities and key infrastructure facilities** suited to the needs of fledgling bioscience companies. Specific space suited to the needs of start-ups in the biosciences is required, as are certain infrastructural investments required to progress commercialization across platforms (such as the planned protein facility at the ISU Research Park). Incubator and infrastructure facility priorities will be established by the Academic Consortium for each platform working in consultation with the university-based technical and business development

assistance staff and with advisory input from the leadership of the statewide commercialization intermediary organization. Funding for incubator and infrastructure improvements will come through the Strategic Technology Platform Infrastructure Fund (see Strategy One, Action Three).

- **Internal senior advocacy positions** to assist faculty entrepreneurs with individual department issues and rapid resolution of any issues related to an individual's entrepreneurship activity. The technical and business assistance staff should work to provide problem resolution services at the department and college levels. Issues, barriers, and problems unable to be resolved at this level should be referred to the Vice Provost for Research office at each university.
- **Industry liaison** and the matching of faculty expertise to firm needs. Formal staff is required at the universities to establish connections between platform research and researchers with industry, host industry visits, arrange for faculty to visit industry, and assist industry in accessing key university bioscience resources. One FTE should be funded for each of the seven platforms (six main platforms and one niche), with the staff person located at the lead university designated for each platform. In addition, the industry liaison should work extensively when appropriate within the existing infrastructure of ISU's Extension activities to help ensure that appropriate connections and linkages are able to be made and encourage Extension assistance and help in implementing this Bioscience Pathway.
- **Technology development/pre-seed funds.** A pool of funds should be established for each of the universities to administer that would be invested in very early-stage investigation of commercialization opportunities based on faculty/university innovations. While the statewide commercialization intermediary organization will be the principal conduit for start-up development funds, additional discretionary funding should be provided to each of the regent universities for use in very early-stage commercialization assessments and business formations. Ultimately, ISU and the U of I should each be allocated $500,000 in annual funds in support of technology development and pre-seed funding, while UNI should initially receive $150,000. In addition, each university should be encouraged to match this investment, doubling the size of the fund.
- **Faculty entrepreneurship success stories.** These success stories should be identified and their use in on-campus communications materials and public relations stories actively promoted. The activities of National Academy members and department heads in patenting and business ventures to help seed credibility and support should be promoted. It is imperative that success stories be shared across campus as part of each university's mission to actively promote and celebrate faculty entrepreneurship and technology commercialization. This function should be housed within the technology transfer office at each institution, with monthly meetings held with each platform to identify communications opportunities.
- **Faculty who have had problems with commercialization.** These faculty members should be identified and engaged to profile the problems they experienced and to assist in work to remove and mitigate barriers. To avoid the promulgation of negative experience stories and to communicate new attitudes and support for faculty entrepreneurships, those faculty known to have had negative experiences should be met with individually to solicit their support for the changes being made. They should be asked to provide advice on changes and also to be circumspect in discussing past problems that may have been resolved or are in the process of being resolved.
- **On-campus bioscience industry and capital events.** Such events should be hosted to showcase the new attitude and support of the universities for technology commercialization, industry collaboration,

and faculty entrepreneurship. They should be followed up with regular communications to these external parties highlighting progress and success stories. Once support staff is in place, procedures refined, and all policies developed, the regent universities should be marketed through a showcase event to the bioscience industry and capital funding organizations.

- **Marketing and communications** activities at each of the regent universities, targeted at proactively marketing each of the platforms to relevant industry groups and related associations. One FTE per platform should be funded to lead the process of marketing the platform and the university's capabilities and services.

Resource Requirements: In total, the university-based technology transfer, economic development, and commercialization activities will require the following annual resources, and it is proposed that these funds be gradually achieved over a 5-year period as detailed in the implementation section of this report.

Activity	Staffing and Operations	Investment Funds and Infrastructure Funds
Proactive mining of university R&D	ISU = $200,000 U of I = $200,000 UNI = $200,000	
Technology transfer and IP protection	ISU* = $3.3 million U of I = $2.2 million UNI = $300,000	
Preliminary technical and business development assistance	ISU = $300,000 U of I = $300,000 UNI = $150,000	$250,000 at ISU and U of I for accessing external expertise and $100,000 at UNI for same.
Incubator facilities and key infrastructure facilities	State support for incubator operations at each university.	Investments as required over time to meet demonstrated demands. Investment through Strategic Platform Technology Infrastructure Fund.
Internal senior advocacy positions	Shared function of staff under technical and business development assistance.	
Industry liaison	ISU = $150,000 for each of three platforms ($450,000). U of I = $150,000 for each of four platforms ($600,000). UNI = One FTE ($150,000) for work across all platforms UNI will engage in.	
Technology development/pre-seed funds	Shared function of staff under technical and business development assistance.	$500,000 to be provided to ISU and U of I. $150,000 to UNI.
Identifying success stories	Shared function of staff in marketing and communications.	
On-campus bioscience industry and capital events	Shared function of staff in marketing and communications.	
Marketing and communications	ISU = $150,000 for each of three platforms ($450,000). U of I = $150,000 for each of four platforms ($600,000). UNI = One FTE ($150,000) for work across all platforms UNI will engage in.	

* Amount for ISU is higher because of high volume of required activity in germplasm and other ag-related licenses.

Time Frame: Immediate

Lead Organization(s): IDED in collaboration with Iowa Board of Regents. Deployment of services and program design the responsibility of the individual regent universities

Action Four: Establish and fund a University Entrepreneurs Center at each university.

Rationale: Faculty members and scientists are obviously intelligent, well-educated individuals. In the sectors of interest to this report, this means that they will be well-versed in science and their specific niche area of bioscience. It does not, however, mean they have any education, background, or experience in commercializing technology or building a business. Just as science is advanced by education, training, mentoring, and collaborations among scientists, so too must be the skills of business venturing and technology commercialization.

While the Pappajohn Centers established across Iowa, in addition to other entrepreneurial support organizations located at the universities, have done an excellent job in coaching a wide variety of businesses, it is recognized that they might not be sufficiently staffed nor have the bioscience-specific experience to offer the type of in-depth assistance that a bioscience entrepreneur may need. Companies interviewed cited the usefulness of the Pappajohn Centers for performing market research and other basic tasks and also for providing access to interns for bioscience companies; however, they also cited the need for the assistance of experienced "serial bioscience entrepreneurs" to help navigate the difficult business climate in which they operate.

It is clear that opportunities for bioscientists to network with experienced entrepreneurs and build their skill set in commercialization have been quite limited and disjointed. Opportunities for frequent networking and for the development of commercialization and basic entrepreneurship skills need to be provided for faculty, research staff, and students.

Action Specifics: Through leveraging the existing framework of entrepreneurial organizational assistance—whether it be by expanding the role of a Pappajohn Center, creating another organization, or blending efforts with initiatives underway at each campus—each University Entrepreneurs Center should focus its efforts on the following activities: organizing and facilitating entrepreneurial events and networking opportunities; providing access to experienced mentors; and driving other initiatives that create a community around faculty, staff, and student entrepreneurship on campus. How these centers are established and their linkages to Pappajohn and other efforts should be decisions made at each campus, reflecting their individual circumstances.

Within the Colleges of Medicine and Engineering at the University of Iowa, an experienced faculty entrepreneur mentoring group is already taking form. This type of structure is to be encouraged at each of the regent universities. Services and mentoring for faculty and student entrepreneurs need to be coordinated through a specific organization at each campus. This may involve leveraging the resources of the Pappajohn Centers; but, in most cases, a formal biomedical entrepreneur's support group will need to be formed.

As a component of the centers, formal on-campus entrepreneurship boot-camp courses should be developed that would be made available on a regular basis for faculty, staff, and students. A university incentive should be provided for participation and completion of the boot camp. In addition, a specialized track for bioscience-related entrepreneurship should be created.

Resource Requirements: $150,000 at each of the regent universities to support formation and initial program development for bioscience entrepreneurship development and support, or $450,000 in total.

Time Frame: Short-term

Lead Organization(s): University of Iowa and Iowa State University, with collaborative support from the University of Northern Iowa

Action Five: Form a statewide commercialization intermediary for supporting, building, and sustaining development of new bioscience business enterprises in Iowa.

Rationale: It is both unrealistic and unfair to expect that universities alone can drive and support technology commercialization and new venture formation in Iowa. While universities are significant centers for innovation and discovery and also can be supportive environments for early steps on the commercialization and business formation pathway, it has been recognized in other parts of the country that a stand-alone intermediary commercialization entity is often the most realistic means of helping to ensure success. In best-practice states and regions, this intermediary resource stands ready to receive the handoff of fledgling commercial entities from the academic sector. Such a resource or entity usually must take the form of a professionally managed, well-funded organization dedicated to facilitating business growth, providing access to experienced management talent, and streamlining business access to the fuel for growth—expansion capital. Currently, in Iowa, such an intermediary organization is needed but does not exist.

Action Specifics: As noted previously, economic development in Iowa should be a priority for all in the state—legislators, administrators, community leaders, business leaders, educators, and the general citizenry. This broader support for entrepreneurship and commercialization needs to be anchored in a state-supported commercialization agency separate from, but working collaboratively with, the university system.

The state commercialization intermediary organization would work to address technology, capital, and talent issues, including the following:

- Assistance provided directly by experienced successful serial entrepreneurs for business plan development, due diligence, market assessments, technology assessments, and other planning activities
- Operation of competitive seed and prototype development funds
- Access to competitive seed and early-stage financing funding, via collaboration with Iowa's state-funded venture financing pools and ag-related venture pools
- Close linkages to private angel investors and the venture capital community
- Access to an experienced pool of managers and operations talent who can staff, mentor, or advise start-up enterprises
- Coordination of, and access to, entrepreneurial and business skill development courses (provided in collaboration with the regent universities)
- Operation of a proof-of-concept/prototype development fund
- Support and advice for accessing SBIR/STTR funds and other sources of early-stage financing.

It is important that the technology commercialization center focus on firms wishing to start and expand in Iowa. In many cases, these firms will have strong growth prospects, but will not always represent the "home runs" on which the formal venture capital community focuses. Yet, these firms represent real opportunities to create wealth and jobs in Iowa.

As noted previously, placing these activities within a stand-alone, state-supported intermediary organization has several advantages:

- It allows for the hiring of managers, personnel, and support staff who are dedicated to and experienced in start-up assistance and entrepreneurship.
- It provides a clear partner organization for universities and other technology commercialization engines, assuring that the burden of state technology commercialization does not fall on them alone.
- It provides private venture funders with a source of business funding opportunities that have been through a proven and professional process of advice, assistance, and due diligence, which all help to lower investment risk.
- It can hire and pay the experienced serial entrepreneurial managers who make this work; their salaries can be covered in part by their administration of a pre-seed fund for biosciences, operation of a prototype development fund, and ongoing coaching and mentoring to start-ups. An additional task of this organization is to recruit such professionals to manage these functions with the intent to locate and place them into senior positions with start-ups within 18 months after being recruited to this intermediary, helping to build a talent capacity in Iowa.

University Role in Industry Clusters

A new report by the Center for Economic Development at Carnegie Mellon University documents case studies of the university role in promoting and sustaining industry clusters, and assesses the factors that are vital to successful university-industry cluster development.

Key factors for universities are:

- **Breadth of Involvement** - engaged universities are sources for research and technology, but also address other important factors such as business, marketing, legal, and workforce issues;
- **Strong Base of Relevant Research and Development**;
- **Regional Alignment** - the university must have the expertise and resources in appropriate areas that align with the needs of the clusters in the region.

According to the report, the characteristics of clusters are also important if there is to be a regional impact. While the university can seed new firms and industries, the region must offer a fertile climate for them to flourish. Key factors related to the industry cluster are its pattern of organization, market trends, and the life cycle stage of the industry or technology.

It is suggested that a requirement be put in place that any state or university-invested funds used in the formation and growth of a bioscience business venture be repaid in full in the event that the business venture locates or relocates more than 50 percent of its operations and staff outside of the State of Iowa.

Resource Requirements: The commercialization intermediary organization should receive $1 million from the State of Iowa to fund its first year of operations. This should rise to $1.5 million in year 2 and plateau at $2 million in annual funding by year 3. This will fund the provision of services outlined above, with the exception of the following additional requirements:

- Prototype Development Fund at $3 million to $5 million capitalized in year 2 of the financial plan from bond financing
- BioSeed Fund at $25 million in capitalization, but whose funding would come from the separately initiated Fund of Funds program.

Time Frame: Immediate

Lead Organization(s): IDED in collaboration with the regent universities.

STRATEGY THREE: FOSTER A BUSINESS ENVIRONMENT THAT SUPPORTS, SUSTAINS, AND ENCOURAGES THE GROWTH AND SUSTAINABILITY OF BIOSCIENCE FIRMS IN IOWA.

Lessons learned from best practices around the nation verify that bioscience-based economies are more likely to thrive in a stable and supportive business environment. Establishing such a climate means achieving alignment in many areas that serve to support bioscience business growth, including

- Business-friendly tax policies;
- Incentives designed to support the needs and opportunities of bioscience companies;
- A quality of life conducive to the attraction of top-quality scientific and business talent;
- Competitive costs of doing business;
- A supportive cluster of businesses achieving agglomeration economies and benefiting from specialized support resources and services that meet their business needs; and
- A network of sector companies and related interests working to drive policies and support programs to enhance the climate for their types of businesses.

Iowa has a business environment that is currently supporting the growth of bioscience companies through programs such as the Iowa Values Fund. However, there are distinct opportunities to improve current bioscience business development conditions in the state. As noted earlier, Iowa was ranked 38th in the nation in the Progressive Policy Institute's *New Economy Index*,[20] so there is certainly room to improve the innovation and business growth environment. It is important to note that this strategy does not attempt to address all the business and operational environment issues that affect Iowa; rather, it serves to highlight those most critical issues that are directly relevant to bioscience cluster growth.

Tactics

The following tactics should be pursued to create a business climate in Iowa conducive to the creation, growth, and retention of bioscience businesses:

- Encourage the development of an overarching, private-sector-driven, bioscience business association for the state that serves to motivate and spur action on business environment issues of greatest import to its membership.
- Critically examine the full suite of economic development services and incentives offered by the state to ensure they meet the current and emerging needs of bioscience sector operations.
- Examine the state's business regulations, tax policies, and legal code to ensure that those aspects of the business environment dictated by the state are conducive to bioscience business development and competitive with those of best-practice bioscience states.
- Continue to brand Iowa as a center for the biosciences, and market and promote the state over the long term to maintain a high bioscience visibility and brand awareness.
- Ensure that economic developers and associated professionals at state and local levels are educated in the specialized needs of the bioscience sector and prepared to provide the support services necessary to promote bioscience industry growth in the state.

[20] http://neweconomyindex.org/states/2002/iowa.html.

Actions for Strategy Three:

Action One: Form the Iowa Bioscience Alliance to facilitate communications, foster joint approaches to issues, and develop a critical mass of support to stimulate actions required to realize Iowa's bioscience vision.

Action Two: Establish a State Bioscience Advocate position, reporting to the Director of IDED, to drive the implementation of this strategy.

Action Three: Implement Iowa's bioscience image and brand through aggressive marketing, public relations, and signature events.

Action Four: Review and make necessary changes to state incentives (including the Iowa Values Fund), tax policies, and legal code to be responsive to the needs of growing bioscience firms.

Action Five: Conduct an economic impact study to measure the projected returns to the state and its regions that are estimated to result from proposed bioscience investments. The study should pay special attention to geographic equity and the diffusion of innovation benefits throughout the state.

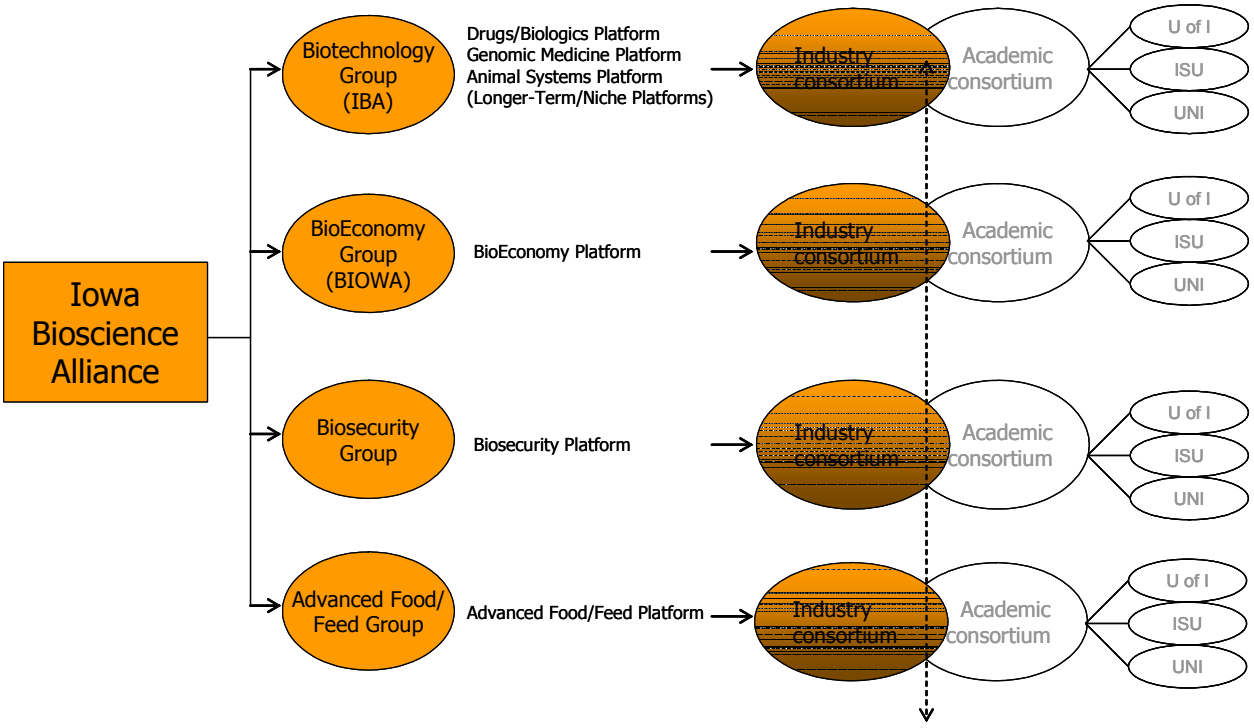
Action Six: Develop a training program for state and local economic development professionals that would include information on university bioscience technology platforms and technical capabilities, the specialized needs of bioscience companies, and programs and incentives that can be used to assist new bioscience ventures and expanding and/or relocating firms.

Action One: Form the Iowa Bioscience Alliance to facilitate communications, foster joint approaches to issues, and develop a critical mass of support to stimulate actions required to realize Iowa's bioscience vision.

Rationale: Unlike traditional manufacturing, technology-driven firms, especially bioscience firms, relish networking opportunities and actively seek collaborations and partnerships. As innovation- and knowledge-driven organizations, bioscience firms tend to attract leadership and management who need to keep abreast of trends in their industry and constantly monitor changes and opportunities that occur in the fast-changing world of bioscience and technology. Networking opportunities also provide introductions to capital sources, service providers, and other important contacts. States and regions trying to build a critical mass of bioscience firms have found that the scale and intensity of networking must be substantial to help spur value-added relationships. Iowa has the beginnings of such a networking organization for the biosciences in the existing IBA and the growing BIOWA development Association for bioeconomy/ biorenewable initiatives. Association operations have not yet been connected along with expanded state government support to provide the type of in-depth assistance and networking opportunities that exist in other leading states.

Action Specifics: Although each of the bioscience platforms impact specialized areas of the biosciences, there will be much commonality of issues and needs when it comes to growing clusters of bioscience firms around these platforms. It is recommended that the common needs, issues, and opportunities be addressed through the formation of a statewide Iowa Bioscience Alliance, an umbrella organization under the IDED that will work with the IBA, BIOWA, and state commodity associations around four specialty bioscience interest groups focused on biotechnology, the bioeconomy, biosecurity, and advanced food/feed. Figure 14 outlines a possible structure for the Alliance, its components, and for industry-academic collaboration on R&D of interest to each sector.

Figure 14: Model Structure for Bioscience Platform Advancement in Iowa: Role of Bioscience Industry with the Iowa Bioscience Alliance



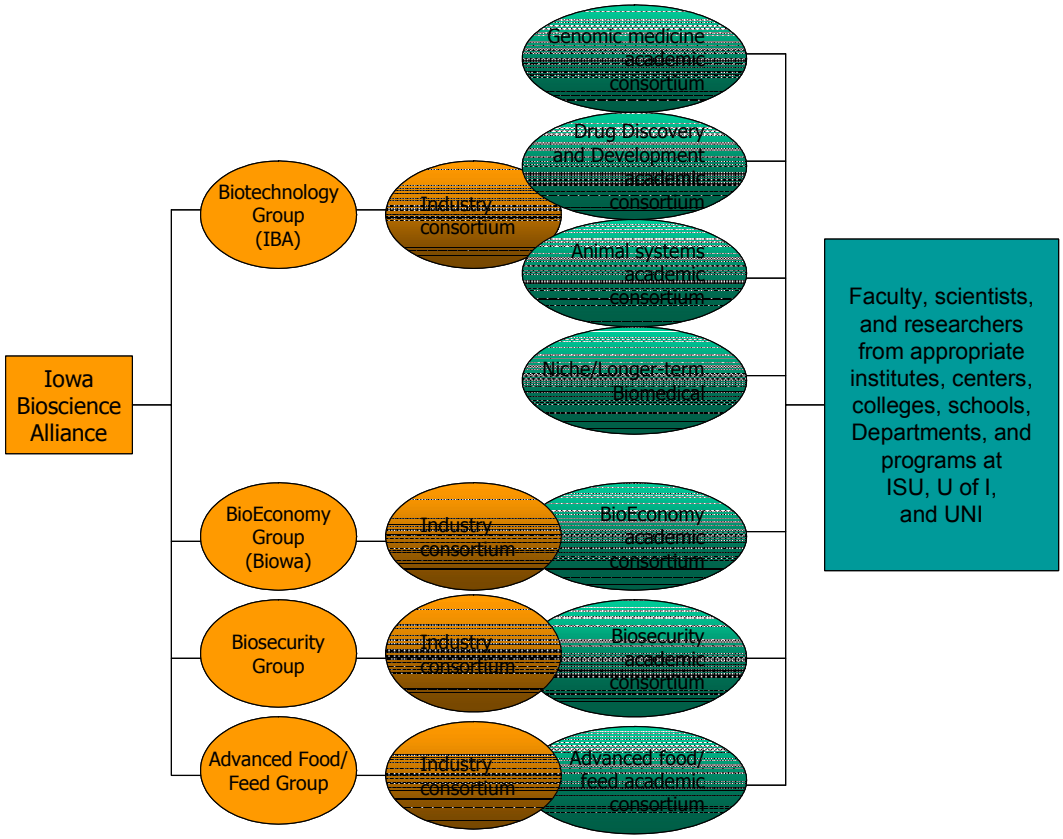
By structuring the Alliance and its subcomponents in this fashion, Iowa will have a single unified entity for providing a shared voice for overall industry and bioscience business environment enhancement in the state. The state also will have a structure that allows for the specialized and unique needs of each bioscience subsector and core platform to be addressed and for guiding joint industry-academic R&D projects of importance to the platform and its members. The industry-university matching grant program (Strategy One, Action Five) would fall within this structure, with joint industry-academic R&D executive committees working to prioritize projects for funding.

The Bioscience Alliance will serve as a unifying organization for the commercial bioscience sector in Iowa, working to ensure that state policies, workforce development initiatives, infrastructure, and resources are aligned to meet the various needs of the sector and its subsectors. The Alliance also must play a key role as a steward for the Iowa Bioscience Pathway, working with the proposed State Bioscience Advocate and Board of Regents Economic Development Director to ensure a unified approach to strategy implementation and associated resource allocation.

Academic Links to the Iowa Bioscience Alliance

In addition to forming a business-oriented bioscience alliance, the structure shown in Figure 14 allows industry to be actively engaged with academia in joint projects in R&D and technology commercialization. At the academic level, each platform could have an "academic consortium." Figure 15 proposes a simplified approach—a single "biotechnology industry consortium" with three main academic platforms and the longer-term/niche platforms as core components (Drug Discovery and Development/Drugs-Biologics, Genomic Medicine, Animal Systems, and the niche biomedical subplatforms). In full structure, therefore, the model would be as shown in Figure 15 for the industry and academic consortia that would be working together.

Figure 15: Model Structure for Bioscience Platform Advancement in Iowa



This model is akin to the collaborative system being used in the BioEconomy platform in Iowa currently, so it builds upon a model already being deployed. At ISU, what Battelle terms "academic consortium" is called a "coordinating council." In either case, each consortium serves to provide collaborative opportunities for researchers, scientists, and faculty from across various constituencies on each university campus to work together on platform-oriented initiatives, research projects, and commercialization opportunities. As discussed in consultation with the universities, each of the academic consortia would be led by those in charge of the academic units identified as existing strengths within each platform, plus an industry representative. Each of the consortia would work to perform the following functions:

- Identify, solicit, and prioritize Iowa research initiatives for the platform
- Work to pull faculty/scientist teams together with the skills to work on prioritized cross-disciplinary initiatives and projects
- Provide input to faculty hiring, infrastructure development, and other key investments crucial to platform development on the academic side
- Prioritize projects for putting forward to the matching grant program with industry and for additional platform-related funding opportunities
- Coordinate the development of federal and additional external support for developing the platform in Iowa

- Coordinate events, conferences, and symposia related to the platform for in-state and out-of-state attendees
- Participate in communications, public and government relations, and other outreach and marketing activities for the platform
- Collaborate with a matching industry consortium that is representative of platform companies in Iowa and (in key strategic areas) outside of Iowa
- Represent the academic side of the platform on a Joint Executive Committee that will comprise industry and academic leaders working together to coordinate university and industry approaches to the development of the platform and associated economic opportunities in Iowa.

Each of the platform-specific academic consortia could have a designated full-time Director and two support personnel located at the lead university. The Director of each platform also could sit on overall university councils at participating universities that serve to coordinate economic development and technology commercialization initiatives. At ISU, such an overall university council exists in the form of the Coordinating Council of Technology Transfer, which also includes representatives from the key colleges, institutes, and IPRT. Ways to accomplish similar objectives should be reviewed by U of I and UNI.

It should be noted that the primary purpose of the platform-specific consortia is to help guide and facilitate the development of R&D initiatives that serve to advance near- or longer-term economic and commercialization opportunities in the platform within Iowa. The consortia provide an umbrella organization under which academicians with interests related to the platform can interact with one another and representatives of industry to work on impactful initiatives. As such, they serve to leverage the academic strengths of Iowa's regent universities in the platform areas to help build and sustain commercial leadership within the state in each platform. The platform consortia will not be responsible for technology transfer, technology commercialization functions, incubators, etc., since those are better operated under individual, university-wide organizational structures at each of the individual regent universities. The platforms will generate practical innovations and advancements, but the commercialization of these innovations will go through university commercialization pathways.

As noted above, there could be corresponding industry consortia to include representatives of industries directly or indirectly engaged within each platform in Iowa (and outside of Iowa in certain instances). To begin with, given the comparatively small base of bioscience companies in Iowa, it is suggested that a general "Biotechnology Industry Consortium" possibly cover multiple platforms on the human and animal biomedical side, with separate consortia formed for Biosecurity, the BioEconomy, and Advanced Food and Feed.

A Joint Executive Committee could be formed for each platform, comprising equal representation from the industry and academic platform consortia. This Executive Committee would serve in the crucial coordinating role for the industry-academe partnership, working to ensure that platform initiatives help advance academic strengths, industry growth, and sectoral economic development for Iowa. The Executive Committee also would form a unified voice for setting priorities and for initiatives aimed at raising the profile of the platform with the state and other external parties. Given the importance of bioscience development to the future of the Iowa economy, it is suggested that the Executive Committee meet monthly.

This model structure has several advantages:

- It brings the universities and industry together to provide input and guidance on key R&D initiatives that present economic opportunities for advancing the platforms in Iowa.
- It does not try to usurp traditional academic independence or research missions, but rather works to provide organizational and monetary incentives that reward industry-relevant research and translational R&D.
- It provides, at the Executive Committee level, a unified voice for each platform, incorporating both industry and academic R&D perspectives.
- It provides a feeder system for commercializable innovations from each platform that will
    - Provide IP for traditional licensing to corporate partners;
    - Provide opportunities for enhanced products for Iowa bioscience companies; and
    - Provide opportunities for new innovation-based start-up companies for Iowa, with these start-ups being served at the earliest stages of formation by each university and then by the statewide commercialization organization.

The initial agenda of the Alliance might include the following items:

- Guidance and advice in the marketing of the state "brand"
- Formation of the academic and industry platform activities itemized above
- Advocacy and support to elected officials to secure the resources needed to implement this strategy.
- Development of an ongoing set of coordinated events and activities among all organizations in the state to increase the scale and intensity of networking in the biosciences
- Formation of one or more work groups to implement key first year priorities of this strategy
- Identification of creative private and public partnerships to implement key actions that otherwise might be resource constrained in their ability to be quickly implemented.

Resource Requirements: The formation and initial staffing of the Alliance should be assisted substantially by state funding at first and then at a reduced level as other partners co-invest in the Alliance over subsequent years. The IDED will provide secretariat support to the Alliance. The state also should provide, as discussed previously, an industry-university matching grant program that will be operated by the Alliance under the direction of the platform/group-specific R&D executive committees. After the first year, the Alliance should be co-funded by the private sector, including utilities that can play an important role in this effort, universities, and government entities. Annual operating costs for the Alliance are anticipated to be $400,000 for the first 5 years, with state funding support peaking in year 1 and declining to $100,000 by year 5.

Time Frame: Short-term

Lead Organization(s): The IBA, BIOWA Development Association, Iowa agricultural associations and commodity groups, and the Iowa Department of Economic Development

Action Two: Establish a State Bioscience Advocate position, reporting to the Director of IDED, to drive the implementation of this strategy.

Rationale: Iowa is unusual in not having a senior administration advisor or science office dedicated to guiding and securing in-state science and technology growth in general. Bioscience economic development, in particular, requires recognition and understanding of the unique and complex economic forces and business development factors that must be in alignment to support growth in this sector and its specialized subsectors. Understanding these factors and working to guide related government policies, funding initiatives, incentive programs, and other development activities need to be the functions of a dedicated senior administration or science director. The biosciences are fundamental to the future of Iowa's economy, and state government must be equipped to receive top-level professional advice and input for ensuring the sector's growth and sustainability.

Action Specifics: Funds should be secured to designate a senior person in the Director of IDED's Office to serve this role and function. Among this person's duties and responsibilities are

- Serving as "eyes and ears" for the biosciences across all of state government;
- Serving as state government's lead person in working with the Alliance (see above) and others in the stewardship of this strategy;
- Advocating within state government for the interests of the biosciences; and
- Identifying and addressing gaps and issues and encouraging appropriate state agencies, departments, and organizations to respond and address these gaps and issues.

In addition, the position also will coordinate with the proposed Economic Development Director on the Iowa Board of Regents (Strategy Two, Action One) regarding proposed initiatives, policies, procedures, and university reporting requirements and information collection.

Resource Requirements: A minimum budget of $125,000 in year 1 to $175,000 in year 5 will be needed to fund this position.

Time Frame: Short-term

Lead Organization(s): IDED

Action Three: Implement Iowa's bioscience image and brand through aggressive marketing, public relations, and signature events.

Rationale: Iowa has a strong image as an agricultural powerhouse state, but it is fair to say that the agricultural life-science expertise of the state has not yet translated into a well-known broader bioscience and biotechnology image. The IDED has been working to create a recently released brand name (life/changing), participate in major exhibits and events (such as BIO), and conduct outreach and communalization activities. It is well recognized, however, that image building and branding is a long-term activity that is only successful through aggressive marketing, public relations, and signature events supported over a decade or longer.

Attracting talent, entrepreneurs, capital, and bioscience businesses to the state requires that Iowa be perceived as a dynamic bioscience hub—a place with many bioscience job opportunities, a constant flow of investable innovation, and a supportive bioscience business environment. The implementation of a believable and sustainable image needs to be focused upon real strengths. Therefore, it is recommended that the marketing activities emphasize the core bioscience technology platforms.

Action Specifics: The state needs to implement a bioscience image and brand campaign through aggressive marketing, public relations, and signature events. Focus groups, use of volunteer public relations firms, and other efforts should be undertaken to formulate a marketing plan focused first in state and then in targeted external markets in the United States and abroad.

Resource Requirements: The State of Iowa currently has a $20 million marketing budget over 3 years for bioscience marketing, including $3 million for advertisements and trade shows. IDED should work with a marketing agency to develop a marketing strategy around the core platforms, reallocating the current marketing budget as required to cover these changes.

Time Frame: Immediate

Lead Organization(s): IDED in collaboration with the new Iowa Bioscience Alliance and the regent universities

Action Four: Review and make necessary changes to state incentives (including the Iowa Values Fund), tax policies, and legal code to be responsive to the needs of growing bioscience firms.

Rationale: The attraction and growth of bioscience and biotechnology business enterprises are highly competitive fields. As other states and regions have come to recognize the pre-eminent importance of the innovation economy and its key constituent components such as the biosciences, they have focused efforts to ensure that their incentive programs, tax code, legal code, and other government-controlled factors are supportive of technology and bioscience sector growth. For Iowa to be a competitive location for attracting and retaining the bioscience industry, it must ensure that its government policies, regulations, and codes are encouraging rather than discouraging Iowa investment. Furthermore, incentives, policies, procedures, and laws should be evaluated to assess their positive or negative impact on entrepreneurship, the start-up of businesses, and the spin-off of technologies from the state's universities.

Action Specifics: The Alliance (see above) should convene a task force of volunteers from business service providers (accountants, lawyers, etc.) to undertake the above-mentioned comprehensive review. Limited loaned staff should be provided by the Department of Revenue. The Alliance should make public its review and recommendations after a 6-month investigation. The review should include an analysis of the Iowa Values Fund, in particular how to extend full, 7-year, funding support. In addition, the review should examine the technology transfer credit to make it a more useful and functional economic development tool for bioscience development.

Resource Requirements: $100,000 in one-time funds will be needed to cover expenses

Time Frame: Short-term

Lead Organization(s): Bioscience Alliance**,** IDED, Iowa Department of Revenue

Action Five: Conduct an economic impact study to measure the projected returns to the state and its regions that are estimated to result from proposed bioscience investments. The study should pay special attention to geographic equity and the diffusion of innovation benefits throughout the state.

Rationale: Iowa is a state characterized by egalitarian attitudes. Given the need for early and intensive support from the state for the bioscience development initiatives outlined in this strategy, it will be necessary to provide persuasive arguments for the diffusion of economic benefits from these investments throughout Iowa. An economic impact study should be conducted to provide projections of the tax,

employment, business volume, and other benefits that may be realized in geographic regions of the state attributable to the projected growth of the bioscience clusters. The impact study should suggest specific actions to help ensure diffusion and equitable distribution of economic benefits to the extent possible and practicable.

Action Specifics: A projections-based economic impact study for the core elements of this bioscience development strategy should be developed. Being a projective model, it will largely require scenario-based impact modeling using examples of specific projects to illustrate diffusion benefits. Input/output analysis techniques will facilitate the measurement of geographic effects induced by a specific bioscience industry. For example, the location of a biorefinery operation in County A can be modeled using input/output analysis to show the monetary and employment effects of its input purchases (such as corn or soybeans) from other counties in Iowa.

Resource Requirements: It is estimated that $100,000 would be required in one-time funds for a professionally produced impact analysis using input/output modeling and case study scenarios.

Time Frame: Short-term

Lead Organization(s): IDED

Action Six: Develop a training program for state and local economic development professionals that would include information on university bioscience technology platforms and technical capabilities, the specialized needs of bioscience companies, and programs and incentives that can be used to assist new bioscience ventures and expanding and/or relocating firms.

Rationale: It should come as no surprise that the specialized needs of bioscience companies present some unique challenges for economic developers. As bioscience development becomes a key emphasis for the state, it will be important that local economic development entities and others providing economic development services be educated in sector drivers, relevant industry needs, and the programs and initiatives available through the state, federal, and other entities to facilitate bio-business growth.

Action Specifics: The University of Northern Iowa's Business and Community Services Division and the Institute for Decision Making (IDM) have a significant track record in coordinating and delivering technical assistance related to business and community development. IDM, for example, has worked with more than 400 communities and regions statewide in the provision of community-based, strategic economic development services. The IDED should contract with UNI's IDM to develop a bioscience business development training course for Iowa's community economic development agencies. The course will work to provide a consistent message and suite of tools for use in promoting and sustaining bioscience economic development in the state. In addition, UNI should serve as a central repository of programs, initiatives, bioscience firm successes, etc., occurring at the local level across Iowa to ensure that all activity is captured and recorded for reporting progress to the Legislature and also to benchmark best-practice activities and successes for incorporating into training and diffusion across agencies in the state.

Resource Requirements: UNI's IDM has experienced funding cuts in excess of 65 percent over the past 3 years. The state needs to reinvest funds into IDM to secure the provision of high-quality bioscience economic development services, training programs, and progress-tracking services. This reinvestment is estimated at $750,000 annually to support UNI's IDM. UNI's IDM currently receives $280,000, necessitating an increase in annual funding of $470,000 that would be phased in over a 5-year period.

Time Frame: Mid-term

Lead Organization(s): University of Northern Iowa

STRATEGY FOUR: INVEST IN AND DEVELOP IOWA'S BIOSCIENCE TALENT POOL.

In the 21st century, economists such as Lester Thurow[21] of MIT are noting that human capital will likely be the key differentiator between winning regions and losing ones. Without skilled people, technology innovation cannot occur and advanced technologies cannot be deployed. Without skilled technical and managerial personnel, capital also is extremely difficult, if not impossible, to secure. In terms of natural resources, the 20th century proved that, while they can be important contributors to wealth, they are not the ultimate determinants of it. Countries such as Japan, Taiwan, Singapore, and South Korea grew to become major international economic forces despite having relatively poor natural resources. Equally, Russia and the former Soviet republics have tremendous natural resources but very low standards of living and economic performance, as do many oil-rich states. Thurow's research suggests that, for the most part, natural resources have ceased to be important sources of economic advancement. It is the talent of people that drives economic success and is the fuel of the innovation and knowledge economy.

In *Workforce Education,* authors Gray and Herr[22] note the following:

> *Among all the riches a nation may possess, its people—its human resources, its human capital—is the most important. The value of this human resource depends not on size, however, but on the occupational and intellectual skills its members possess. At least in this regard history is clear: a large "unskilled" population is a detriment to national economic growth and to a high standard of living.*

The root cause of economic progress, higher wages, and higher standards of living in modern western society can be found in high levels of workforce productivity—gained in part by technology, but mostly through the skills and ingenuity of the people who use and maintain that technology. Only through increasing levels of productivity can standards of living grow; and it is the nations, regions, communities, and individual firms that have the highest-skilled workforce, other factors held constant, that will be the most productive, produce the best products or services at the lowest costs, earn the highest profits, and dominate markets.

The lesson to be learned is a simple but profound one—developed nations, states, and regions cannot compete on the basis of low wages but must, instead, seek to create a high-skills workforce that will enable firms to be innovative, efficient, pay high wages, and still be price competitive. The strategy for a state like Iowa is to make the state's workforce so productive that they can produce more than those in competing locations—thereby attracting the growth of industry in the state and raising the overall standard of living. This must be accomplished for the bioscience sector, as it must be in all focus sectors of the Iowa economy.

Much has been written about the rise of "knowledge" as the driver of the U.S. economy. This rise is an accepted fact, but there is much misunderstanding of who those with "knowledge" are. Some have interpreted this to mean that a 4-year college-degreed elite is the route to economic success, but the fact is

[21] Thurow, L. *Head to Head: The Coming Economic Battle Among Japan, Europe and America.* New York: Morrow and Company. 1992.
[22] Gray, Kenneth C., and Edwin L. Herr. *Workforce Education.* Massachusetts: Allyn and Bacon. 1998.

that skills and knowledge are increasingly required across the total workforce. The creative elite (scientists, engineers, clinicians, etc.) may be a critically important driver of invention and new products and services, but this can encompass only a small proportion of a state's labor force. The rest of the workforce must produce the output of creativity and innovation in volume and do so at a higher level of productivity than can be achieved elsewhere. Gray and Herr note as follows:

> *If the route to success is inventing new products, the education of the smartest 25 percent of the labor force is critical. If the route to success is being the cheapest and best producer of products, new or old, the education of the bottom 50 percent of the population moves to center stage. This part of the population must staff those new processes. If the bottom 50 percent cannot learn what must be learned, new high-tech processes cannot be employed. If the education of the bottom half moves to center stage, so too must workforce education, which we have defined as education and training below the baccalaureate level.*

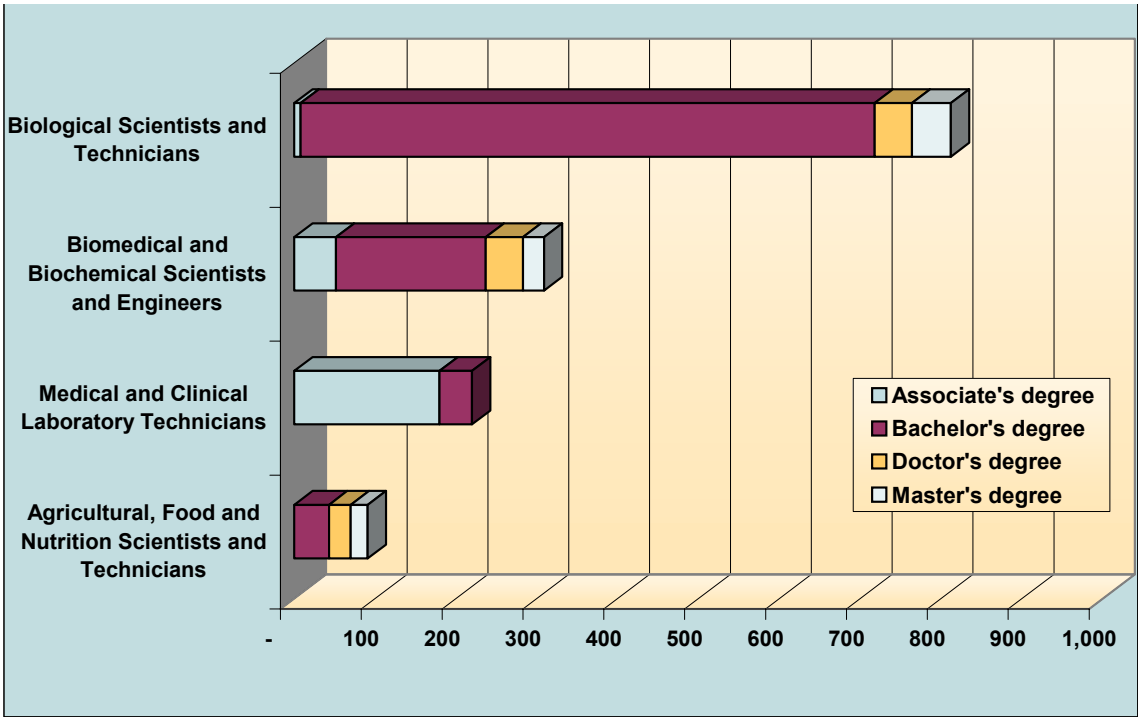
The implication for Iowa is critically important for all involved in economic development to grasp. It is that, in a 21st century economy driven by high productivity and increasingly skilled processes, an unskilled workforce is no resource at all. It is only a "potential" resource, and that potential can be realized only through workforce education and skills development.

It also must be noted that technology and productive processes are being improved or supplanted at a rapid pace—especially in revolutionary fields such as the biosciences. In such a fast-paced, change-oriented working environment, a workforce has to be equipped with the personal learning skills and adaptability traits required to keep pace. Life-long learning is becoming a necessity because most workers cannot expect their jobs to continue to be done as they are now, or even to exist at all in a recognizable form a decade from now. In this economic environment, Iowa cannot afford to produce a workforce output that has low levels of academic literacy, skills attainment, and adaptability.

Skilled people drive the knowledge economy; therefore, skilled people drive the bioscience economy. The bioscience degree offerings provided at both the regent universities and the private universities found across Iowa position the state quite well in terms of higher educational degree opportunities (Figure 16). Overall, the 4-year higher education system in Iowa has a distinct track record of innovation and talent development in key bioscience, science, and engineering disciplines. In addition, the breadth of services offered by ISU Extension serve to reinforce education and workforce development in the state, not only in agricultural production and processing but also in nonagriculture-related manufacturing and industry through Manufacturing Extension and CIRAS. In addition, Iowa is blessed with a comparatively high-performance K-12 education system and a large and well-resourced network of community colleges.

Therefore, fundamental building blocks for high-performance talent development are in place, but refinement is necessary to fully meet the challenges of a bioscience-based knowledge economy. Iowa also has been experiencing a talent drain, as its talented graduates are recruited to out-of-state employment centers by the promise of higher wages, a quality for life perceived to be more dynamic or exciting, or a broader cadre of technology businesses in which to build and advance their careers. Retaining talent and attracting talent are as important to Iowa's future as growing talent at home.

Figure 16: Bioscience Degrees from Iowa Institutions, Academic Year 2002



Tactics

- Supporting a growing bioscience industry base will require an increased flow of talent at all skill levels that have the basic training required for success in the bioscience positions they pursue. As a primary tactic, Iowa must work to assure that the K-12 and higher education sectors are teaching the skills and knowledge for a high-productivity bioscience workforce.
- Four-year and graduate degrees are important; but, to realize a complete bioscience value chain, the bioscience production sector will require entry-level workers with strong basic skills and semiskilled and skilled production and technical workforce with appropriate vocational training. A key tactic for Iowa will be the development of bioscience career academies, 2+2 programs between schools and the community colleges, and other innovative workforce training programs.
- In an environment requiring life-time learning and reskilling, it is important to ensure that the skills and credits earned in one form of education transfer to programs teaching the next order of skills and educational attainment. Articulation across education levels and educational institutions thus becomes a key tactic.
- In addition to developing home-grown talent, Iowa must jump-start its bioscience entrepreneurial, technical, and managerial workforce through attracting such experienced personnel to live and work in Iowa.

Actions for Strategy Four:

Action One: Improve K-12 scientific education by focusing on stimulating interest among Iowa's children in science, thereby preparing them for careers in Iowa's growing bioscience sectors.

Action Two: Develop a bioscience vocational career education program and ensure seamless delivery between secondary and community college programs that serve Iowa's growing concentration of bioscience employers.

Action Three: Streamline bioscience articulation agreements within and between community colleges and Iowa's regent universities to allow students to transfer credits between academic institutions.

Action Four: Leverage alumni associations and the state's Human Resources Recruitment Consortium to attract to Iowa bioscience professionals, including experienced bioscience managers.

Action One: Improve K-12 scientific education by focusing on stimulating interest among Iowa's children in science, thereby preparing them for careers in Iowa's growing bioscience sectors.

Rationale: Too few American youths choose math, science, and engineering and associated technical disciplines as their education path. At a time when technical education is necessary to drive the innovation economy, the number of Americans entering scientific and technical education programs has declined dramatically.[23] Between 1985 and 1997, the number of B.S. degrees in engineering in the United States fell 16 percent; computer science and math degrees fell 29 percent. Only 12 percent of all degrees awarded in the United States are in technical areas. Forty-eight percent of all Ph.D. graduates in technical fields in the United States are foreigners, and increasingly these foreign graduates are not retained in the United States; they are attracted home by the opportunities brought by increasing globalization. These trends are echoed at the pre-baccalaureate level, with declining enrollments in technical 2-year programs. This trend has led the Pennsylvania Economy League to conclude that "a region that does not have a growing percentage of its 'non-professional' workforce trained at the post-secondary pre-baccalaureate level will face increasing difficulty attracting and keeping high value added employment."[24]

States are producing technology, but they are not getting the model right to produce a solid flow of value-added production from their innovation. Iowa, with its traditional strengths in education, has a distinct opportunity to leverage this tradition to produce enhanced levels of students with high-school education and 2-year technical and B.S./M.S./Ph.D. degrees in the biosciences and related technical and scientific disciplines. Building a world-class technical workforce will provide a major advantage for Iowa in attracting, building, and retaining skilled talent for bioscience cluster and economic growth. Doing so requires that Iowa's students and youths be introduced to the biosciences as a clear, high-value career path for the future and that demand be generated among students for scientific and technical training at all levels.

Action Specifics: If Iowa is to compete in today's knowledge-based economy, the state must commit to engaging students in scientific or technological careers. It is recognized that a child should be introduced at an early age to mathematics and the sciences; otherwise, he or she will quickly fall behind and be unprepared to study collegiate engineering or scientific curricula.

[23] Gray, Kenneth, and Edwin Herr. *Other Ways to Win: Creating Alternatives for High School Graduates*. Thousand Oaks, California: Corwin Press, 2000.
[24] Pennsylvania Economy League. *Building a World-Class Technical Workforce*. Philadelphia. 1996.

Recommendations for potential initiatives to improve scientific education and engage additional students include the following:

- **Aligning standards, curricula, assessments, and accountability.** Through a standard-based approach, significant strides can be made to increase student achievement and meet the expectations of the 21st century. Standards, including English/language arts, mathematics, science, and technology standards, are an essential foundation for the state's workforce. In addition, an entrepreneurial curriculum can be "extracted" from Iowa's academic and technical standards. Project-based experiences and senior capstones bridging both sets of standards provide students an entrepreneurial environment. Other promising practices and professional development must focus on the entrepreneurial "spirit" and the need to integrate mathematics, science, and technology in the elementary and high schools.
- **Supporting specialty high schools.** New school designs and deliveries (science and technology academies/magnet schools, small learning communities, and technology cluster programs) support Iowa's economic development vision and are an asset for the state. Programs such as this call for a connected and comprehensive educational system. However, it is important to recognize that, without the needed scholarships to support students who achieve excellence in quality secondary programs, Iowa will lose its best and brightest. Other states have successful strategies, such as loan forgiveness programs in New Jersey, Georgia, and Pennsylvania, which encourage students to enroll and remain in higher education as well as stay in the state.
- **Developing programs and initiatives designed to interest students and parents in technology.** It is generally agreed that students choose early in their educational careers to take the necessary math and science classes to prepare them for advanced work in technological fields. Therefore, it is very important that technology careers are promoted so that students can see the benefits of pursuing a scientific course of study. All schools also should have "invention" laboratories supporting broad career exploration, authentic strategies for academic instruction, and opportunity for student creativity in solving problems. Student experiences (technology competitions, technology mentors, higher education summer enrichments, etc.) contribute to a climate of high expectations and opportunities. In addition, funding should be made available to support middle, junior, and high school student and teacher experiences in technological fields.
- **Using distance education technology to bring high-quality math and science instruction to students in all parts of Iowa.** While it may be unrealistic for every community in Iowa to provide advanced science and math courses, students should be given the opportunity to take such courses via distance learning technology.
- **Instituting a differential pay scale or incentive system that allows science and math teachers to be more highly compensated.** In today's market, it is extremely difficult to recruit math and science teachers given the opportunities available to people with scientific and technical degrees. Yet, improving math and science education will require the ability to recruit teachers with math and science credentials. Consideration should be given to providing a salary differential or other financial incentives for math and science teachers.

Resource Requirements: To be determined based on discussions with the educational community

Time Frame: Mid-term

Lead Organization(s): Iowa Department of Education in collaboration with community colleges and regent universities

Action Two: Develop a bioscience vocational career education program and ensure seamless delivery between secondary and community college programs that serve Iowa's growing concentration of bioscience employers.

Rationale: As noted above, knowledge creation usually requires a pool of talent educated beyond the baccalaureate level; but, true economic growth and sustainability comes from producing the output of that knowledge in a high-productivity, high-wage environment—and that requires solid bioscience and technical skills at the pre-baccalaureate level. In areas of Iowa where clusters of bioscience employers are located, it will be particularly important to sustain the growth of these businesses by developing production-level talent and technicians. Iowa's strengths in community college education and in developing career academies and other linkages between K-12 and community college programs provide a distinct advantage to leverage in this arena. For instance, Indian Hills Community College (IHCC) has recently been awarded a $775,000 grant from the U.S. Department of Labor to serve as a Biotechnology Center of Excellence. IHCC will work to develop skill standards and workforce data for the bio-technology industry. This resource should be leveraged as Iowa develops its bioscience workforce development programs.

Action Specifics: As Iowa's economy changes, so too must the delivery of its educational system. The ability of students to move seamlessly and smoothly from one level of education to the next in their chosen field of study to obtain their ultimate educational goal—an associate's degree, bachelor's degree, or advanced degree—is critical. This seamless integration is achieved through enhancing real partner-ships among all educational institutions in Iowa that result in students achieving their long-term learning goals. However, Iowa's current system is often fragmented, and students cannot easily transfer their technical courses from high school to community college or university. State articulation agreements (secondary to postsecondary as well as postsecondary to postsecondary) are necessary to provide a seamless pathway for students, minimize duplication, maximize resources, and offer a common resource to industry.

An example of a model that Iowa could implement is Ohio's College Tech Prep Program, which is a very viable means of expanding an articulated curricular pathway from vocational school through college for high-tech careers. Beginning in the junior year of high school, College Tech Prep students begin a seamless, nonduplicative pathway with rigorous academic preparation aligned with advanced technical skills, culminating in at least an associate's degree at a community or technical college with articulation provided through the baccalaureate degree. The product of the College Tech Prep Program is a highly skilled technology worker ready for a career in business and industry. Preparation is focused on high-skill, high-tech occupations. The most recently developed curricula are in information technology and biotechnology.

Iowa should institute a similar program between its vocational/high school programs and its community colleges. In addition, articulation programs need to be expanded to include all the various levels of the educational system.

Resource Requirements: $500,000 initially to develop the curriculum

Time Frame: Mid-term

Lead Organization(s): Iowa community colleges

Action Three: Streamline bioscience articulation agreements within and between the community colleges and Iowa's regent universities to allow students to transfer credits between academic institutions.

Rationale: If education and skills development are prerequisites to progress in the knowledge-driven bioscience economy, and if life-long learning is a likely component of such skills development, it is imperative that education credentials and coursework be portable across various levels of education delivery. Just as efficiency is necessary in industry, it is also necessary in education and training (especially in today's high-cost educational environment). Against this background, it is highly important that Iowa's public and private education system be structured to allow the vast majority of course credits earned at one level of education to be transferred to degree or certificate courses within the same level and between the next highest level. At the current time, the great majority of community college credits earned in biology and other bioscience-related disciplines will not transfer to bioscience degree programs at the U of I and ISU. Such policies hamper education efficiency and drive up the cost of education to the state and its citizens—they also dissuade citizens from continuing along a pathway of increasing educational attainment. If the problem is that community college courses are not being taught in a way that makes the credits suitable for transfer acceptance, then the courses must be changed as appropriate. If the problem is that the universities simply want to maximize revenues by having students retake coursework, then they should be dissuaded from such activity by the state and the Board of Regents. UNI has made significant progress by developing articulation agreements with every community college in Iowa. To achieve this result, the Provost appointed an industrial technology professor to work with each community college in Iowa. This person focuses on articulation agreements, 2+2 programs, distance programs, etc. Alignment of course-taking pathways and liberal articulation agreements need to be the norm across Iowa's public education institutions.

Maryland—Montgomery College, Montgomery Public Schools, and the Universities at Shady Grove: Early Placement and University Partnership

Montgomery College, the Community/Technical College for Montgomery County, Maryland, has developed relationships with the Montgomery County Public Schools and the universities at the Shady Grove Life Science Center to offer a 2+2+2 program of technical education. Beginning with the last 2 years of high school, the program continues with 2 years and an associate's degree from Montgomery College and offers the option of completing another 2 years for a bachelor's degree.

The first phase, the Montgomery County Public Schools Tech Prep Program, allows high school students to receive college credits for grades of B or better if they major in the corresponding program at Montgomery College. As of the 2001-2002 academic year, students are eligible to receive credit in one of 22 college programs, including biotechnology. The high school biotechnology program is housed at the Thomas Edison High School of Technology and offers intensive laboratory experience, interaction with scientists and technicians from local research facilities and firms, and leads for summer and college internship opportunities.

Once the student completes the second phase and earns an associate's degree from Montgomery College, he or she may choose to continue working toward a bachelor's degree at the Shady Grove Center. Eleven University of Maryland System institutions are involved in the partnership.

Action Specifics: A joint working committee should be established between the regent universities and the community colleges in Iowa that are providing, or intend to provide, a bioscience education track in their 2-year programs. The regent universities should be clear in outlining the curriculum required for

credits to be transferable into the universities' bioscience and related curriculum. In addition, to the extent possible, articulation agreements with the private universities in the state also should be pursued.

Resource Requirements: No direct costs should be involved.

Time Frame: Short-term

Lead Organization(s): Board of Regents, community colleges, academic colleges and departments, and the IDED

Action Four: Leverage alumni associations and the state's Human Resources Recruitment Consortium to attract to Iowa bioscience professionals, including experienced bioscience managers.

Rationale: Iowa's higher education strengths have led to Iowans being natural targets for the recruitment efforts of colleges, employers, and regions from outside of Iowa. A substantial volume of skilled Iowans, and persons educated at Iowa institutions, exists throughout the United States. These are people who have experienced Iowa first hand and who may be attracted back to the Midwestern quality of life enjoyed in the state. Current talent reattraction initiatives and alumni engagement activities being undertaken by the state and its institutions should be considered high priorities for talent-driven economic development strategies in the biosciences.

A growing literature on brain drain demonstrates that in the absence of the rudiments of a technology-based regional economy, the best and brightest most likely will leave. We are convinced that aggressive, mission driven research universities can counteract that trend and contribute to the building of regional knowledge economies.

Tornatzky, Louis, Paul Waugaman, and Denis O. Gray. "Innovation U.: New University Roles in a Knowledge Economy." Southern Growth Policies Board, 2002.

Action Specifics: Continued support needs to be provided to the Iowa Human Resource Recruitment Consortium, a unique public-private partnership created to meet Iowa's need for highly skilled employees. Members include the IDED, Iowa Workforce Development, communities, businesses, educational institutions, and professional associations throughout the state. The Consortium is a comprehensive marketing initiative, working to increase the pool of qualified skilled individuals considering Iowa career opportunities and to successfully network these individuals with Iowa employers. The cornerstone of the campaign is SmartCareerMove.com, an interactive Web site that includes a job bank of professional/technical positions in Iowa and a resume bank and information on working, living, and playing in Iowa. The Web site lists available jobs in the recruitment expertise areas at annualized salaries of $30,000 or more. Also included is comprehensive information on living in Iowa, recreation in Iowa, and business in Iowa, with links to hundreds of communities, businesses, and cultural and recreational activities throughout the state. The Web site has received more than 8 million hits since October 1998, and numbers continue to increase.

Resource Requirements: The Human Resources Recruitment Consortium is already funded, and this activity can be undertaken through priority setting within current funding.

Time Frame: Short-term

Lead Organization(s): IDED and alumni associations and alumni relations organizations within the regent universities

SUMMARY

This section of the report proposed a vision for Iowa's future as a leading Midwestern state with a comprehensive set of strengths in the animal, plant, and human sciences. This vision is to be achieved through the execution of four strategies involving 20 actions, in addition to leveraging the significant investments Iowa has made to date through programs such as the Iowa Values Fund. Because the private sector must make many of the investments critical to achieving this vision, the state government's role is one of facilitator and catalyst, addressing and helping fill gaps that have not or cannot be addressed by the private sector alone. These "gap-filling" actions, however, are designed to leverage significant private and other funds. Many are one-time actions that, if successful, will enable the private sector to move forward without need for ongoing renewal of the state's investments. Other investments are annual and long term, such as building the state's higher education R&D base. The strategies and actions address the three key drivers of the state's bioscience future—technology, capital, and talent. The next section will offer guidance in implementing the strategic priorities.

Implementation Plan

The previous sections of the report evaluated Iowa's position in the biosciences by outlining Iowa's current bioscience base (in terms of both industry and research bases); identifying Iowa's core competencies in the biosciences; assessing the state's competitive position and its bioscience development strengths, weaknesses, opportunities and threats; outlining a vision and mission for Iowa's bioscience development; identifying gaps to be addressed; and proposing a four-strategy, 20-action program to address gaps and significantly improve Iowa's standing in bioscience development for the next 10 years. This section of the report, the Implementation Plan, lays out the major actions critical to success, immediate priorities, resource requirements, and organization and structure for moving this roadmap forward.

The implementation plan for the Iowa Bioscience Pathway is designed to catalyze public and private sector collaboration and public sector investment, focused on filling "market gaps" that the private sector cannot or will not undertake on its own. But addressing gaps, while necessary, is not sufficient. The State of Iowa will need a committed set of public and private sector leaders and champions working to raise funds and secure support for the specific strategies and actions outlined herein. This commitment will need to be sustained over the next decade to ensure that necessary changes are made, gaps filled, and actions taken.

Wherever possible, existing entities' roles and responsibilities should be expanded to implement the recommended strategies and actions. Reconstituting or using existing organizations and programs wherever possible in the implementation plan should be preferred. Stakeholders should be encouraged to use this approach where it makes sense in terms of being efficient and, equally important, in terms of achieving results.

Critical Actions

To realize the full bioscience economic potential that this roadmap lays out, Iowa must successfully implement certain critical actions. Specifically, the ultimate success of the strategy hinges on the forward movement of six activities, in essence Iowa's bioscience critical path. In other words, it is these six critical actions that are most significant to, and the underlying foundation for, the eventual success of the other proposed elements and initiatives of this strategy. Therefore, when initial resource allocations are being determined, efforts must be made to ensure that the following critical actions receive funding priority:

- Form a Strategic Technology Platform Infrastructure Fund **to reinforce the core bioscience platforms** by supporting faculty recruitment, entrepreneurial endowed chairs, and other key actions. The fund will be directed through academic consortia set up to develop the six bioscience platforms. Financed perhaps by issuing bonds and from other sources, the fund also would provide infrastructure and equipment funding to reinforce the platforms.
- **Develop and implement policies and procedures at the regent universities** to ensure the highest level of encouragement and support for private-sector partnering, commercialization, and entrepreneurship.
- **Form a statewide intermediary for supporting, building, and sustaining development of new bioscience business enterprises in Iowa**. This organization will proactively assist Iowa's bioscience

entrepreneurs and provide business development services to companies formed from university-based technology transfer and commercialization efforts and from other sources of intellectual capital.

- **Form the Iowa Bioscience Alliance** to serve as a guiding force in engaging industry in the strategy implementation and stewardship. Connect the Alliance to the proposed academic consortia to be formed around the bioscience platforms to ensure industry/university collaboration of platform R&D and commercialization of innovations.
- **Institute an industry-university matching grant program** dedicated to the identified bioscience technology platforms to boost bioscience R&D collaborations between academia and industry in Iowa.
- Increase funding to the regent universities to **allow for sufficient staffing and resources for commercialization activities.**

The above actions will ensure that the strengths of the current core bioscience platforms are leveraged and further built; that industry and academe work together on joint R&D initiatives to develop commercial innovations from each platform; that funding and support are available to develop bioscience entrepreneurs and their business ventures; and, that the regent universities are optimally leveraged for the bioscience-based economic development of the state.

IMMEDIATE PRIORITIES

Immediate work plan priorities are those steps that should be undertaken in the first 12 months of strategy implementation, regardless of how critical they are to the overall strategy. Several immediate priorities can be implemented right away, while others will need to be planned and allocated funds before they can become fully operational. The following actions should be undertaken in the first year:

- Create and fund an Economic Development Director position on the Iowa Board of Regents to provide catalytic support for regent university economic development initiatives.
- Develop and implement policies and procedures that actively encourage faculty entrepreneurship and commercialization activities at the regent universities.
- Engage Iowa's Congressional Delegation in discussions pertaining to federal funding and specific project support.
- Institute an industry-university matching grant program dedicated to the identified bioscience technology platforms to encourage relationships between academic researchers and industry.
- Increase funding to the regent universities to allow for sufficient staffing and resources for commercialization activities.
- Form a statewide commercialization intermediary for supporting, building, and sustaining development of new bioscience business enterprises in Iowa. The commercialization organization will work to address technology, capital, and talent issues.
- Implement Iowa's bioscience image and brand through aggressive marketing, public relations, and signature events.
- Leverage alumni associations and the state's Human Resources Recruitment Consortium to attract to Iowa bioscience professionals. An initial emphasis should be placed on attracting individuals with experience in bioscience management.

RESOURCE REQUIREMENTS

For each action, Table 17 indicates the priority of the action, breaks down state funding needs into two 5-year phases, provides the estimated one-time costs, and indicates the anticipated external leverage. Table 18 breaks down the proposed revenue sources to be allocated from the state for this financial plan. Overall, costs to the state government include both general fund appropriations that would require new state dollars of $47.4 million over Phase I (years 1 to 5 of this effort) and bond financing for capacity building of $96.8 million for infrastructure, recruitment, and matching support. In Phase II (years 6 to 10), new state funds of $84.3 million would be required and bond financing for further capacity building of $73 million would be needed. One-time costs are included in these bond financing totals of $169.8 million over 10 years. External leverage to these investments are estimated over the entire 10-year period at more than $1.5 billion.

Table 17: Iowa Bioscience Pathway Financial Plan

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Capacity building in the key platform areas	Short-term	Consortia: $1.2 M increasing to $2.0 M by year 5 Matching grants: $1.7 M increasing to $3.8 M—this item covered under Infrastructure Fund	Consortia: $2 M per year rising to $5 M by year 10 Matching grants: $3.8 M staying constant years 6-10	$10.188 M annually for first 5 years for platform investments, or $50.94 M from the bond-financed Strategic Investment Fund (see below)	9:1 federal funding leverage based on other state performance
Entrepreneurial Endowed Chairs program	Short-term	$2 M per year for 3 years and $1 M in year 4	Second round of additional chairs: $3 M for 3 years and $1.5 M in year 4		2:1 (match to state funds)
Strategic Technology Platform Infrastructure Fund		This Fund supports above actions in capacity building of platforms and endowed chairs as well as matching grants item below and one-time costs of these and prototype fund		$169.44 M capitalization via bonds with $96.76 M in Phase I 5-year period and $73 M in Phase II 5-year period.	

Table 17: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Engage Iowa's Congressional Delegation for federal funding	Immediate	Existing resources	Years 6 through 10 rise from $3.0 M to $5.0 M		
Industry-university matching grant program	Immediate	Initial year funding at $1.5 M rising to $3.0 M by year 5			3:1 (match to state funds)
Economic Development Director position on the Iowa Board of Regents	Immediate	$150,000 per year	$175,000 per year		
Policies and procedures that actively encourage faculty entrepreneurship and commercialization	Immediate	$200,000 per year	$240,000 per year		
Funding to the regent universities for commercialization activities/tech transfer	Immediate	$2.9 M in year 1 increasing to $9.55 M in year 5 Mining: start at $300,000 and increase to $600,000 by year 5 TT: start at $1.5 M and increase to $5.8 M by year 5 Business dev: start at $300,000 and increase to $750,000 by year 5 Industry liaison: start at $300,000 and increase to $1.2 M by year 5 Marketing and communications: start at $500,000 and increase to $1.2 M by year 5	Increase by 10% per year or: Year 6: $10.5 M Year 7: $11.55 M Year 8: $12.71 M Year 9: $13.98 M Year 10: $15.38 M	$1 M to be covered as infrastructure funds from Strategic Infra-structure Fund	6:1 leveraged return in increased sponsored research, licensing revenue, and equity in start-ups
Establish a University Entrepreneurs Center	Short-term	$450,000 per year	Years 6 and beyond increase to $600,000 per year		

Table 17: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Form a statewide commercialization intermediary	Immediate	$1 M year 1 $1.5 M year 2 $2 M years 3, 4, and 5	Years 6 and beyond increase to $2.2 M per year	$3 M to $5 M Prototype Development Fund over first 5 years and similar amount for years 6-10 financed by Infrastructure Fund $25 M to $50 M initial capitalization for BioSeed Fund as part of Fund of Funds (nondirect state) and privately financed thereafter	Leveraged 6:1 return in private funds, sales, and other income
Form the Iowa Bioscience Alliance	Short-term	$400,000 in year 1 decreasing in year 5 to $100,000	Ongoing support in years 6 and beyond of $100,000 per year		Leverage 3:1 private, university, and other funds
Establish a State Bioscience Advocate position	Short-term	$125,000 in year 1 increasing to $175,000 in year 5	$200,000 in year 6 increasing to $300,000 in year 10		
Implement Iowa's bioscience image and brand through aggressive marketing	Immediate	As currently budgeted IDED			
Review and make necessary changes to state incentives, tax policies, and legal code	Short-term			$100,000 for study and review in year 2	
Conduct an economic impact study for bioscience strategy	Short-term			$100,000 for study and review in year 1	

Table 17: Iowa Bioscience Pathway Financial Plan (continued)

Action	Priority	Annual State Funding by Year: Years 1-5	Annual State Funding by Year: Years 6-10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds
Develop a biosciences-development training program for state and local economic development professionals	Mid-term	$470,000 for UNI's IDM operations funded (currently they are at $280,000) beginning in year 2 through 5	Maintain funding at $470,000 per year in years 6 through 10		
Improve K-12 scientific education	Mid-term	To be determined			
Provide articulation agreements between K-12 and community colleges in bioscience education	Mid-term			$500,000 in year 3	
Streamline bioscience articulation agreements within and between community colleges and universities	Short-term	Existing resources			
Leverage alumni associations and the state's Human Resources Recruitment Consortium	Immediate	Existing resources			

Table 18: Financial Plan by Year and Proposed Sources of Revenue (state funds only—dollars in millions)

Year	Total State Investments	Bond Financed	General Fund Support
1	21.913	16.588	5.325
2	30.193	22.633	7.530
3	29.878	19.738	10.140
4	30.158	18.813	11.345
5	32.083	18.988	13.095
Subtotal Year 1-5	$144.225	$96.76	$47.435
6	26.685	12.200	14.485
7	33.930	18.350	15.580
8	31.265	14.500	16.765
9	32.195	14.150	18.045
10	33.265	13.800	19.465
Subtotal Year 6-10	$157.340	$73.000	$84.340
Grand Total	**$301.565**	**$169.76**	**$131.775**

ORGANIZATION AND STRUCTURE

State science and technology initiatives are most effective when they are executed on a bipartisan basis, with strong executive and legislative branch support, involvement, and cooperation. States such as Pennsylvania, New York, Maine, Maryland, and North Carolina have been successful with their science and technology investments because their efforts have been broad based, they have mobilized private sector champions behind them, and their initiatives have become institutionalized into both economic development and higher education at state and regional levels.

The following deficiencies indicate that Iowa is less than optimally organized to develop its bioscience-based economy:

- No Science and Technology Office, Science and Technology Advisor, or Bioscience Advocate at the state government level. As a result, policies are more likely to be enacted in an *ad hoc* fashion, rather than following a formal strategic plan and pathway.
- No economic development function coordinated at the level of the Iowa Board of Regents. Thus, the individual universities hold sole responsibility for setting strategy and actions.
- Declining funds to support regent university economic development, technology transfer, and commercialization activities. With budget cuts of more than 60 percent in the past 3 years, the regent universities have seen their organizational capacity in these key functions drastically reduced.
- Small and comparatively under-resourced bioscience-related industry organizations (such as the IBA and BIOWA). Therefore, they are limited in the services and bioscience development initiatives they can undertake.
- No clear bioscience-development imperative being set at the state level and then understood and implemented within the academic, non-profit, and industry sectors.
- No clear organizational and assistance structure for would-be bioscience entrepreneurs to follow in terms of accessing business development assistance, prototype development, pre-seed/seed funding, management talent, expansion capital, etc.

To help solve these organizational deficiencies, the Iowa Bioscience Pathway proposes a set of strategies and actions that involve multiple public and private organizations and entities. These strategies and

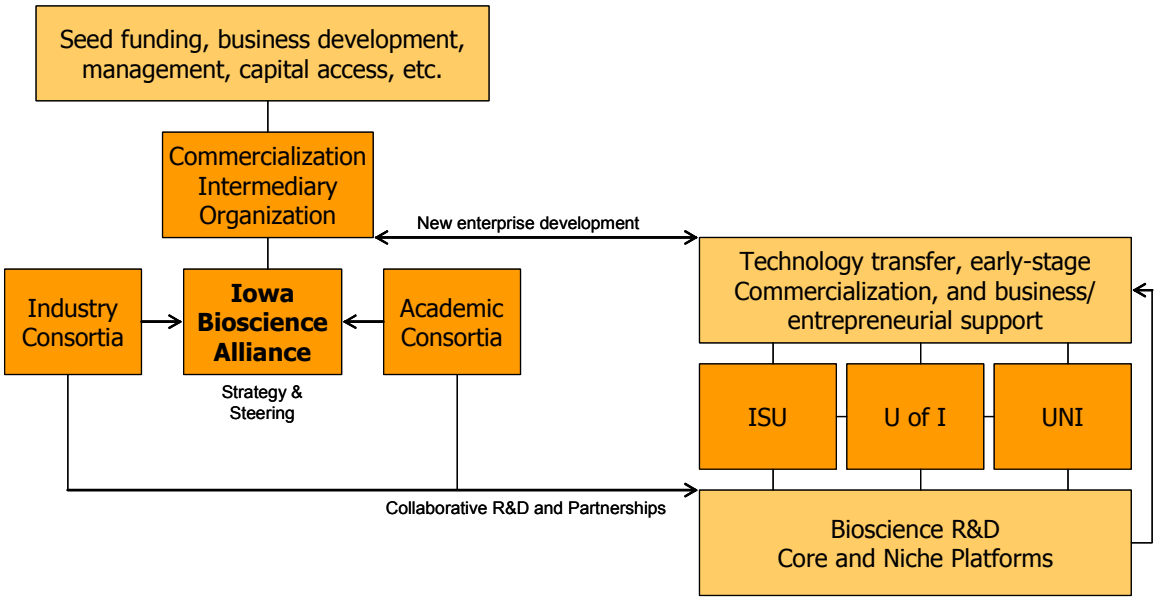
actions have been designed to build on the base of organizational capabilities that currently do exist in Iowa, and to provide resources and structure for redirecting efforts for these organizations and the formation of new organizations for plugging critical gaps.

Directing and administering the implementation of the Iowa Bioscience Pathway are critically important functions. Given the important role that industry, academia, and government each must play, it is imperative that an organization be structured that will engage each of these groups in the process. The logical convening entity would be the Iowa Bioscience Alliance (as shown in Figure 17). The Alliance, staffed and financially supported by the Iowa Department of Economic Development, would be a formal collaboration between industry and academe. Industry and academic consortia, established for each bioscience platform, would be the core constituent components of the Iowa Bioscience Alliance, working to advance applied bioscience R&D in the state. In addition, it is proposed that the commercialization intermediary organization directly report to the Alliance.

The Iowa Bioscience Alliance Board should include key public and private representatives including the following:

- The State Bioscience Advocate
- Iowa Regents Economic Development Director
- Director of the Iowa Department of Economic Development
- Provosts for Research from each of the Regent Universities
- Dean of the University of Iowa College of Medicine
- Dean of Iowa State University College of Agriculture
- Vice Provost for Extension at Iowa State University
- Representatives from the Community Colleges
- A legislative representative from each caucus of the Iowa House and Iowa Senate
- Chair of the Iowa Capital Investment Board
- Board President of the Iowa Capital Investment Corporation
- Industry representatives from the following businesses:
    - Biotechnology and Bioprocessing
    - Drugs and Pharmaceuticals
    - Biorenewable Fuels
    - Biorenewable Chemicals or Fiber Products
    - Food Processing
    - Agricultural Processing
    - Agricultural Production
    - Medical Devices, Sensors, and Imaging Equipment
    - Biosecurity
    - Utilities
    - Economic Development Organizations.

Figure 17: Basic Organizing Structure of Iowa Bioscience Development



The structure proposed for the Iowa Bioscience Alliance is similar to that of the Georgia Research Alliance (Figure 12). The GRA is a nonprofit organization that focuses on building a strong research base in Georgia's higher education system through endowed chairs, infrastructure and facilities improvements, recruiting packages, matching funds, and related programs. Beginning in 1990, a consortium of Georgia's business leaders conceived and founded the GRA to leverage the state's research universities with the state's economic development. GRA has managed to leverage state funds many times over. Since 1992, the State of Georgia has invested more than $300 million and established endowments for 37 Eminent Scholar positions. GRA also invests in the physical infrastructure for conducting research and commercialization. More than 40 research facilities and centers of research excellence have had their construction, renovation, modernization, expansion, or equipment needs supported by GRA investments.

The Iowa Bioscience Alliance will focus on research excellence and technology commercialization around the key bioscience platforms described earlier in this report. The independent nature of the Alliance, with its highly representative board, will facilitate the funding of projects of merit and potential economic development return for the State of Iowa.

Measures of Success and Accountability

The following measures and performance goals, to be monitored on an ongoing basis by the Iowa Bioscience Alliance, should be used to determine the successful accomplishment of performance objectives:

- There will be more than 130 new bioscience business start-ups in Iowa by 2014.
- Iowa's location quotient in all the biosciences will exceed 1.4 to 1.5 by 2008, compared with 1.24 in 2002.
- Iowa will increase its university R&D funding (primarily from federal sources) for bioscience-related research from $291 million in 2001 to $700 million by 2010 and more than $900 million by 2014.

- The state will leverage at least $5 in federal and other dollars for every $1 of state support.
- There will be substantial implementation progress on the actions outlined in this pathway—at least 70 percent will have substantial action after 3 years and 90 percent within 5 years.

10-Year Economic Impact

The state's proposed investment of $302 million in bond financing and general fund support over the next 10 years will leverage an estimated $1.5 billion in federal, industry, and other funds. This level of investment is projected to translate into more than 5,100 private sector jobs through new and relocated firms, as well as from an additional 10,950 private sector jobs from an indirect multiplier impact on other industries and businesses, for a total projected impact of 16,050 jobs by the year 2014. These numbers likely will increase substantially in a 15- to 20-year period as the exponential impact multiplies again and again. Total sales in year 10 are projected at nearly $1.4 billion.

Although it takes considerable time for state and private investments to have measurable impacts on a state economy, it is important to note that the overall economic impacts surely will include some that cannot be projected such as additional increases in direct university employment and retained private sector jobs with higher skills and better pay.

Conclusion

Iowa has the opportunity to build its economy through the application of advanced biosciences. Indeed, given the state's agricultural-bioscience expertise, its leading-edge work in biorenewables, and its distinct strengths in various areas of human and animal medicine, the biosciences represent the most logical path to a high-productivity, high-wage, 21st century economy. Iowa already is beginning to see distinct progress around advanced areas of bioscience; but, a definite opportunity exists to accelerate the process and optimize the growth of these sectors in the state.

This pathway for development lays out a detailed approach to accomplishing bioscience-based economic development in Iowa. The strategy puts forward a bioscience agenda that effectively integrates the private, public, and academic sectors in Iowa into a unified driving force for development centered on Iowa's bioscience platform strengths. In addition, the pathway seeks to leverage the significant momentum that already has been built through the state's investments in programs such as the Iowa Values Fund.

However, for Iowa to succeed in achieving its bioscience vision, the state must take a comprehensive approach that addresses each of the key recommendations in this strategy. Strengthening Iowa's bioscience research infrastructure will result in jobs and income for the citizens of Iowa only if research findings are commercialized and new companies created based on technological innovation. Similarly, for commercialization to be successful, there must be a steady pipeline of discoveries. To retain and grow bioscience firms, firms must feel that Iowa supports them in its policies and regulations. And lastly, if Iowa's economy is to benefit from innovation in the biosciences, the state must have a talent pool ready to fill the new jobs created in bioscience companies. A comprehensive and integrated approach is needed for Iowa to become a significant player in the biosciences.

Iowa already has made great strides in agricultural biotechnology and has even greater opportunities to develop its economy around the biosciences in the future. Iowa has an open window of opportunity to continue and expand its leadership position, or place among the leaders, in each of the core platforms identified.