



CENTER FOR CROPS UTILIZATION RESEARCH
AND THE COLLEGE OF AGRICULTURE AT
IOWA STATE UNIVERSITY:

RECOMMENDATIONS FOR ENHANCING AGBIOSCIENCE ECONOMIC DEVELOPMENT

PREPARED FOR:
Iowa State University Center for
Crops Utilization Research

PREPARED BY:
Battelle
Technology Partnership Practice

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The Business of Innovation

Recommendations for Agbioscience Economic Development at
CCUR and College of Agriculture at ISU

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the College of Agriculture at Iowa State University:**

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Abbreviations

AC/IT	advanced communications/information technology
APEL	Applied Process Engineering Laboratory
ARS	Agricultural Research Service
BioSTAR	Biotechnology Strategic Alliances in Research
BSL	Biosafety Level
BU	Boston University
CAES	College of Agriculture and Environmental Sciences
CAGT	Center for Applied Genetic Technologies
CATD	Center for Advanced Technology Development
CCTEC	Cornell Center for Technology, Enterprise, and Commercialization
CCUR	Center for Crops Utilization Research
CDFIN	Center for Designing Foods to Improve Nutrition
CEO	Chief Executive Officer
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
ERC	Engineering Research Center
FDA	Food and Drug Administration
GIVF	Grow Iowa Values Fund
GM	genetically modified
GRA	Georgia Research Alliance
HP	Hewlett-Packard
I2I	Idea to Innovation Program (Canada)
IDED	Iowa Department of Economic Development
IFF	Indiana Future Fund
IP	intellectual property
IPRT	Institute for Physical Research and Technology
IRAP	Industrial Research Assistance Program (Canada)
IRTP	Industry Research and Technology Program
ISU	Iowa State University

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ISURF	Iowa State University Research Foundation
MCG	Medical College of Georgia
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NBTC	Nanobiotechnology Center
NESPAL	National Environmentally Sound Production Agriculture Laboratory
NIGMS	National Institute of General Medical Sciences
NIH	National Institutes of Health
NLSI	New Life Sciences Initiative
NMR	Nuclear magnetic resonance
NRC	National Research Council (Canada)
NSERC	Natural Sciences and Engineering Research Council (Canada)
NSF	National Science Foundation
NYSAES	New York State Agricultural Experiment Station
NYSTAR	New York State Office of Science, Technology and Academic Research
OCR	Office of Corporate Relations
OEDTV	Office of Economic Development and Technology Ventures
OTD	Office of Technology Development
OTL	Office of Technology Licensing
PBI	Plant Biotechnology Institute (Canada)
PI	principal investigator
PNNL	Pacific Northwest National Laboratory
PRF	Purdue Research Foundation
R&D	research and development
SBIR	Small Business Innovation Research
SEN	Stanford Entrepreneurship Network
SRC	Saskatchewan Research Council
STC	Science and Technology Center
STTR	Small Business Technology Transfer
SUNY	State University of New York
TPP	Technology Partnership Practice
UCSD	University of California at San Diego

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UGA	University of Georgia
USDA	U.S. Department of Agriculture
VIDO	Vaccine and Infectious Disease Organization (Canada)
WSU	Washington State University
WTC	Washington Technology Center

Executive Summary

INTRODUCTION

Technology is transforming the U.S. economy, spurring innovation and productivity gains. As a result, the consumer is witnessing both a stream of new products and the emergence of entirely new industries. Applying new technologies to traditional industries has likewise changed the economic landscape. This overall shift emphasizes intellectual capital and knowledge, rather than raw materials or physical labor.

The agricultural bioscience (agbioscience) sector is a knowledge-based industry cluster driven by innovation in the life sciences. When researchers, scientists, and engineers make new discoveries in plant and animal genetics, healthcare, ecology, or nutrition, the entire industry can change. Continuous innovation and change characterize this dynamic industry and lead to economic opportunities. Technological breakthroughs and scientific insights are applied to new products, delivering both economic and social benefits around the world. Today, agriculture is not only a producer of food and other goods, but also a leader in affecting public health and the environment.

With the convergence of technology, the biosciences, and a traditional economic base in agriculture, many regions around the United States are diversifying and enhancing their local economies. To successfully commercialize research and development (R&D), a state or locality must promote clustering among these diverse but related activities and leverage its comparative advantages. Agricultural producers might provide their goods as inputs to manufacture bio-engineered fuels or botanical and medicinal products or pharmaceuticals. In addition, farmers can adopt biotechnology practices to help breed healthier animals, develop disease-resistant crops, or grow their products in a more energy-efficient manner. A state can reap the benefits of the agbiosciences through better jobs and a stronger economic future.

In recognition of the opportunities for Iowa through agbioscience R&D, the Iowa State University (ISU) College of Agriculture has sought to assess its structure and position for maximizing economic development from its R&D activities. The College has a sound track-record in developing and diffusing technology and advanced agbioscience practice that has enhanced the viability, sustainability, and productivity of Iowa agriculture and agri-business. However, the quantum advancements in the modern biosciences have opened new and enhanced pathways for large-scale, technology-driven development in the state's agbioscience economy. Because of this, the ISU College of Agriculture wants to ensure that it is positioned and structured to leverage its R&D strengths to benefit economic growth and progress in Iowa.

To assist in its strategic planning for economic development, the College of Agriculture requested the Battelle Memorial Institute's Technology Partnership Practice (TPP) to evaluate the College's activities and capabilities and recommend actions that will enhance its economic development potential.

Given the broad nature of the College of Agriculture's work, it was further decided that, to benefit the College, the review would provide in-depth strategic insight for one of the College's most applied R&D centers—the Center for Crops Utilization Research (CCUR). Thus, Battelle evaluated CCUR's structure, operations, and impact areas to provide recommendations for CCUR that will also apply to enhancing the

economic development outcomes of all centers, institutes, and departments under the direction and influence of the College of Agriculture.

In 2004, Battelle conducted a formal evaluation of the bioscience economy and bioscience R&D core competencies in Iowa¹. The analysis identified six platforms for bioscience-based economic development in Iowa:

- **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 Practices production into an integrated pipeline of new drugs and therapeutics.
- **Advanced Food Products Platform**—Using Iowa’s established strengths in plant and animal sciences, production agriculture, food science, nutrition, and processing technology to develop and produce functional foods and nutraceuticals.
- **Integrated Post-Genomic Medicine Platform**—Using Iowa’s genomics expertise and specific disease/disorder skills, in conjunction with epidemiologic data and Iowa’s stable population, to produce rapid advances in post-genomic medicine and associated discoveries.
- **Animal Systems Platform**—Using Iowa’s bioscience expertise to establish a leadership position in modeling animal systems and developing technologies and applications for transgenic animals, chimeric animals, and cloning.
- **Integrated Biosecurity Platform**—Deploying the strengths of Iowa’s institutions in human, animal, and plant disease prevention, protection, and treatment to establish an integrated approach to securing the environment, food production systems, and human health and safety.

In referencing these platforms, it is clear that agriculture and agbiosciences are critically important to four of the six: the **BioEconomy Platform**; **Advanced Food Products Platform**; **Animal Systems Platform**; and **Integrated Biosecurity Platform**.

When set against this background, the central importance of ISU College of Agriculture to achieving progress in Iowa’s bioscience-based development strategy is evident. Thus, the College of Agriculture and its constituent centers and institutes must be optimally structured to advance innovations into practice and on-the-ground commercialization within the State of Iowa.

CCUR plays a key role in applied R&D development and application in three of the agbioscience platforms—the **BioEconomy Platform**; **Advanced Food Products Platform**, and **Integrated Biosecurity Platform**. Because of its influence across multiple platforms, and its direct applied engagement with industry, CCUR serves as an excellent “case study” upon which to build recommendations for actions and initiatives within the ISU College of Agriculture designed to enhance economic development.

Goals and Key Tasks of the Review

Battelle was engaged by the College of Agriculture to undertake the following specific tasks:

¹ *The State of Iowa Biosciences Path for Development: Economic and Core Competency Analyses*, prepared by Battelle TPP for the Iowa Department of Economic Development (IDED), March 2004, <http://publications.iowa.gov/archive/00001771/01/iowareport.pdf>.

- To identify how other public and private institutions that engage in contract research and commercialization in similar environments have successfully established strong technology commercialization and technology-transfer programs (include non-agricultural and failed enterprises);
- To review College of Agriculture and CCUR resources and advise how to make them more effective in meeting the needs of Iowa for economic development; and
- To advise the College and CCUR how to structure and respond to meet the recommendations in the *Iowa's Bioscience Pathway for Development*² so that the College and Center will be able to optimally use potential new resources through the BioAlliance, Grow Iowa Values Fund, and other state and federal bioscience development funding sources.

In conducting the research and associated strategic planning, Battelle undertook several key assignments, including the following:

- Interviews with ISU faculty and leading research teams
- Interviews with senior ISU College and academic leaders
- Interviews with Iowa-based agbioscience and bio-based businesses related to the key agbioscience technology platforms
- Interviews with agricultural commodity associations and promotional groups
- Interviews with key Iowa economic- and university-development professionals
- An assessment of key data on ISU performance in economic development, commercialization, and agbioscience development
- A review of best-practices and programs in agbioscience development at six leading agbioscience research institutions.

It should be noted that Battelle focused its research on CCUR as a case study, rather than on the College of Agriculture as a whole. Conclusions and specific recommendations are made with regard to CCUR, with more broad based observations and recommendations pertaining to the College as a whole.

BENCHMARKING AND BEST PRACTICES OF COMMERCIALIZATION EFFORTS

Each individual benchmarking summary contains insight that may be of value to ISU, the College of Agriculture, and CCUR in making operational adjustments. Taken together, however, the benchmarking institutions illustrate that the following are key factors in determining the success of agbioscience-based economic development, innovation, commercialization, and entrepreneurship:

Entrepreneurial Culture

The culture of entrepreneurship on campus is probably the single best predictor of success at commercialization. Some institutions seem to have industry partnership in their culture, although a great deal of this is determined by environmental factors beyond the reach of campus policy and programs. Programs analogous to the Iowa Values Fund—the Indiana 21st Century Fund, the Georgia Research Alliance (GRA) Innovation Fund, various programs of the Canadian federal government affecting

² *Iowa's Bioscience Pathway for Development*, prepared by Battelle TPP for the IDED, July 2004, <http://publications.iowa.gov/archive/00001773/01/IowaStrategicReport704.pdf>.

Saskatchewan, or several New York State programs leveraged by Cornell—are most effective when they are embraced by campus leaders *as levers for changing the culture of the faculty as a whole*, rather than funding for specific deliverables only.

In addition to the monetary incentives provided by state-level funds, universities are able to *leverage access to new, high-quality laboratory space to encourage the commitment they seek* to interdisciplinary collaboration, industrial partnership, and entrepreneurial activity. This is the essence of the space programs launched at Purdue’s on-campus Discovery Park. Faculty receive access to this space as their primary research home only if they are committed to this kind of activity. Similar examples include Arizona State University’s new BioDesign Institute where faculty, in order to retain prime space, must generate outside income of so many dollars per square foot. It is important to note that the original CCUR model included faculty incentive space, but it is no longer available as originally intended.

Faculty Recruitment

Closely related to culture is the question of staffing. Some institutions, such as the Pacific Northwest National Laboratory, enjoy the advantage of hiring scientists and engineers who are not subject to traditional academic requirements, incentives, and reward structures, allowing them to focus particularly on staff with insight into industrial requirements and needs. However, *even traditional academic institutions may leverage external programs to recruit faculty who both meet traditional standards of excellence and are committed to seeking industry partnerships*. Examples include the University of Georgia’s use of the Eminent Scholars program of the GRA to hire faculty experienced in industry and in starting companies.

Walking the Halls

One way that the right people can affect culture is to “walk the halls,” in the celebrated manner that founders Hewlett and Packard pursued at HP, looking for opportunities for commercialization that more traditional researchers may not recognize or may not be ready to pursue without heavy personal support. Such *scouts or entrepreneurial coaches* can be either faculty or professional staff, but they must possess the faculty’s trust in their scientific and technical knowledge, business acumen, and personal integrity and understanding of the academic environment. This is definitely the model employed at the University of Georgia, leveraging the Venture Lab program of the GRA.

Professional Staff Hiring

However, as also clarified by Georgia’s experience, the faculty inventor of a technology that is being commercialized through a spin-off may not be the correct leader for the start-up. Often, *an equally important element of staffing is a class of early-stage business planners and “launch CEOs”* who can begin formal fund-raising for a venture newly formed around a university-owned discovery by planning and executing commercialization research that reduces technical risk and laying out detailed milestones. Often, this process can be assisted by money available from state-level programs similar to those previously mentioned and integrated with business incubators. More recent evolutions of this theme is the growing support for executives in residence/executive corps programs that recruit serial entrepreneurial

Key Success Factors

- Entrepreneurial Culture
- Faculty Recruitment
- Walking the Halls
- Professional Staff Hiring
- Economic Development Focus
- Flexible Commercialization Funds
- Interdisciplinary Approach
- Top-to-Bottom Commitment
- Communications and Awareness Building

managers to populate these spin-offs. Examples include the Life Sciences Greenhouse in Pittsburgh and the BioGenerator in St. Louis.

Economic Development Focus

It is worth stressing that launching new ventures *is a job that few university licensing offices are budgeted or staffed to accomplish themselves*. Nor should a traditional licensing office be expected to launch new ventures. This activity is more properly called technology commercialization, distinct from technology transfer, for it requires different skills and aptitudes. Scouting faculty laboratories for commercialization opportunity is not fully compatible with the skill set for which licensing officers are recruited and compensated. It nearly always seems desirable to embed this function within an economic development unit, often within a separate nonprofit organization associated with, but not part of, the university, whose focus is long-term returns to the university as opposed to the short-term benefits of maximizing licensing revenues.

Flexible Commercialization Funds

Sources of flexible funding are key to moving technology into the marketplace. However, there are often few, if any, sources of very early-stage funding to assess the commercial potential of a new discovery. Small amounts of funding that does not require repayment are needed to conduct testing, validate the technology, and determine whether it meets a market need at a competitive price. Examples include Venture Lab in Georgia and Ag-West Bio in Saskatchewan.

Interdisciplinary Approach

In examining commercialization in the context of agricultural research, which is used more as a model of information dissemination and extension, it becomes evident that *an interdisciplinary approach is critical*. Campuses such as Purdue, where agricultural researchers cross paths freely and often with colleagues in engineering, enjoy the advantage of the engineering “ethos” of industrial partnerships applied to agricultural discovery. Similarly, the willingness of agricultural researchers at Georgia to meet their colleagues in the arts and sciences on the common ground of the biosciences has enabled this University without a medical school to become a source of commercial spin-offs with biomedical applications.

Top-to-Bottom Commitment

Finally, one of the most important features of any institution with some success at commercialization and industrial partnership is a top-to-bottom commitment to a common vision. In Saskatchewan, Battelle was told that “everyone from the cabinet minister to the cab driver” carries the same message: the region is Canada’s leader in plant biotechnology and (now) the bioeconomy generally. At Purdue, the creation of a university-wide, presidential cabinet for “engagement” conveys the message clearly that all divisions of the university wish to serve the state’s economy. No cultural transformation can take place without support from working-level faculty and staff; but, that support is best accomplished with clear and consistent expectations backed with resources from the top of the institution.

Communications and Awareness Building

The strengths, research competencies, programmatic activities, and areas of assistance must be understood by key audiences, especially potential industry partners in strategic sectors, if the economic benefits of these centers are truly to be recognized.

SITUATIONAL ANALYSIS

With an understanding of the importance of an applied research center to the state economy, and informed by the lessons learned from the benchmarked case studies, Battelle conducted a series of in-depth interviews with ISU faculty and staff and industry and trade association representatives, which provided considerable insight regarding ISU’s current position in agbioscience-based economic development. From the interviews it was determined that, while both the College and CCUR are providing important pathways for agbioscience-based economic development in Iowa, further improvement can be achieved, thereby helping Iowa to succeed in this high-growth opportunity area for economic development and growth. Table ES-1 outlines key success factors in agbioscience-based economic development and describes the current situation at ISU and key gaps to address in the future to achieve success.

Table ES-1. Commercialization Gap Analysis

Key Success Factors	Current Situation	Gaps
<p>Entrepreneurial Culture A broad culture of entrepreneurship, supported on campus by leaders at the highest university levels, is critically important.</p> <p>Incentives at multiple levels are required, including: a well-recognized faculty rewards structure, high-quality laboratory and commercialization space incentives, access to the latest equipment, and monetary incentives and support.</p>	<p>Multiple funding resources are available to support early-stage commercialization and entrepreneurial development activity. However, faculty members are confused as to the institutional imperative to engage in industry-sponsored or commercialization-oriented work. Faculty members feel little incentive to engage in translational or commercial research.</p> <p>ISU is in the early stages of creating an entrepreneurial culture. While some start-ups have formed out of the University, faculty in general do not feel it is a university imperative and young faculty perceive it as an activity with little formal reward or incentive.</p>	<p>Faculty perceive multiple barriers to industry engagement and commercialization activity, most notably in terms of a lack of recognition for such activities in tenure and promotion decisions.</p> <p>Increased industrial engagement is needed. To achieve this, additional university, college, and department reward and incentive structures are needed to encourage industry partnerships and commercialization initiatives.</p>

Table ES-1. Commercialization Gap Analysis (continued)

Key Success Factors	Current Situation	Gaps
<p>Faculty Recruitment Faculty should be hired who both meet traditional standards of excellence and are committed to seeking industry partnerships.</p>	<p>ISU colleges and departments have few resources available to hire new faculty. The hiring of faculty with commercial interests, industry partnerships, or an entrepreneurial track record is not a university priority.</p> <p>In addition, by not replacing faculty who had focused their research on critical areas of CCUR’s mission, the Center’s productivity has been negatively impacted in areas such as fermentation, lipid chemistry, grain processing, and process engineering.</p>	<p>Additional resources for new faculty hires are needed. Also, concern has been expressed regarding the slow pace to fill vacant positions and make hiring decisions.</p> <p>There is a need for additional focus on hiring industry-engaged and entrepreneurial faculty. Currently, there is no strategic plan or long-range vision for building a faculty dedicated to both scholarship and economic development.</p>
<p>Walking the Halls There should be a formal program that mines faculty labs for early-stage innovations suitable for potential commercialization. Connecting researchers with promising technology to industry partners who are able to commercialize it is a critical step in the commercialization process.</p>	<p>Mining technologies is not a centralized university function. It happens on a more <i>ad hoc</i> basis through center and institute connections. Process is more passive (faculty seeking help when they have an idea) than active (university aggressively searching for innovations with commercial potential).</p>	<p>CCUR needs an increased level of staff resources required to actively mine the University for innovations, technologies, and faculty interested in engaging with industry. Currently, the College of Agriculture has no single staff person or unit dedicated to this function.</p>
<p>Professional Staff Hiring Professionals are required who understand entrepreneurial enterprise development, early-stage business planning, and business management. Encouraging interactions between university researchers and industry can help to ensure that researchers are aware of both developments in the marketplace and the technological challenges facing specific industries, thereby driving research that is more likely to lead to discoveries with commercial potential.</p>	<p>Professional staff exist at various levels of sophistication in multiple pockets across campus. Plant Sciences Institute has dedicated staff in this arena, for example. At a University-wide level, services are available through the ISU College of Business’s Pappajohn Center for Entrepreneurship and resources at the ISU Research Park.</p>	<p>Needed is a highly visible one-stop shop for first contact, advice and assistance regarding technology commercialization, entrepreneurship, and industry partnering.</p> <p>A centralized capability is needed within the College of Agriculture to focus on agbioscience-based commercialization opportunities.</p> <p>There is limited evidence of university-based agbioscience market intelligence capabilities in early-stage technology evaluation.</p>

Table ES-1. Commercialization Gap Analysis (continued)

Key Success Factors	Current Situation	Gaps
<p>Economic Development Focus A dedicated focus by key leadership to champion economic development initiatives is imperative.</p>	<p>Multiple parties are partly responsible for industry liaison and partnerships, IP protection, tech transfer and licensing, and business development support. However, there is no accepted university strategy for economic development in general or for ag-based economic development specifically.</p>	<p>There is a need for a university economic development strategy based on accepted core competencies and statewide strategic technology-development priorities. This will require an ISU office for economic development coordinating relevant resources across colleges, institutes, and centers, building on the current work of the Office of the Vice Provost for Research.</p>
<p>Flexible Commercialization Funds Sources of flexible funding are key to moving technology into the marketplace. However, there are often few, if any, sources of very early-stage funding to assess the commercial potential of a new discovery. Small amounts of funding that does not require repayment are needed to conduct testing, validate the technology, and determine whether it meets a market need at a competitive price.</p>	<p>ISU colleges and departments have few resources available for commercialization.</p>	<p>Commercialization funds, whether pre-seed, seed, or mezzanine funds, are not readily available.</p> <p>Faculty do not have access to critical bridge funding that allows them to invest in an innovative idea and develop it to a proof-of-concept stage at which additional outside funding sources could be available.</p>
<p>Interdisciplinary Approach Ag-innovation development projects need multiple skills, often including basic sciences, agronomy, engineering, chemical engineering, food science, business studies, etc., working collaboratively.</p>	<p>Multiple centers and institutes encourage interdisciplinary thinking and collaborations across ISU. Multiple individual institutes and centers provide broad capabilities; however, they are not tied to a coherent strategy or organizational hierarchy for achieving development.</p>	<p>There is a need for an awareness of capabilities, resources, and skills across departments, colleges, and centers.</p> <p>There is a need to establish a rewards structure to encourage collaborative project opportunities.</p>

Table ES-1. Commercialization Gap Analysis (continued)

Key Success Factors	Current Situation	Gaps
<p>Top-to-Bottom Commitment Universities are hierarchical organizations, and a common vision regarding commercialization and industry partnering is imperative. Expectations must be clear, consistent, and backed with resources.</p>	<p>Board of Regents is in conflict with IDED and the BioAlliance over management and control of economic development-oriented university funding. Many faculty want to be engaged in platform development, but perceive that the process has been usurped by more traditional academe seeking to assign monies to more basic, and perhaps non-strategic, projects.</p>	<p>Demonstrated commitment and strategic direction related to platform development from highest levels of university administration are needed.</p> <p>Needed is formal and widely communicated economic-development strategy formed by the University or its individual colleges.</p> <p>Additional resources are needed for some centers and institutes lacking the operational funding support and staffing necessary to accomplish their economic development missions.</p>
<p>Communications and Awareness Building The core competencies of the University must be understood well by key audiences, especially potential industry partners in strategic sectors.</p>	<p>Industry demonstrates relatively low levels of awareness of the capabilities, resources, and interests of ISU, including comparatively low levels of awareness of the capabilities of the College of Agriculture and individual departments and centers related to it, such as CCUR. Industry does not perceive ISU as placing a high priority on industry work and commercialization.</p> <p>Currently, limited collaborative working relationships exist with the largest agricultural processors operating in the Midwest and other individual companies in strategic sectors (such as food processing, biofuels, chemicals, etc.).</p>	<p>Stronger outreach and communications programs targeting lowa industry in strategic sectors are needed.</p>

STRATEGIC RECOMMENDATIONS

A number of key gaps relate primarily to the commercialization capability and commitment to engaging with industry and pushing technologies actively forward into economic development. There is a distinct need for development of a strategy for agbioscience-based economic development, and university policies and procedures must be restructured to encourage and incentivize industrial, commercial, and entrepreneurial applied R&D activities.

However, it is important to note that ISU has certain commercialization elements in place (such as a research park, IP protection and technology transfer office); but, these are only pieces of what needs to be a wholly integrated system for encouraging and supporting applied industrial R&D relationships, innovative commercialization, and in-house faculty entrepreneurship. Many key elements of such an integrated system (proven to be effective at other institutions) still remain to be built at ISU. As such, the recommendations contained herein primarily concentrate on actions that CCUR, the College of Agriculture, and ISU should undertake to build capacity in commercialization support and entrepreneurial development.

It is also important to note that the science and functional R&D activities of CCUR and the College of Agriculture are not the primary focus of recommendations herein because:

- 1) The quality and direction of current R&D programs are well established and, based on the findings of detailed interviews with CCUR researchers and affiliated faculty, well suited to building strong opportunities for economic development activity.
- 2) Major changes in scientific direction will not achieve major economic development gains for the state unless the basic university cultural shifts and commercialization support activities recommended herein are first initiated.

Instead, the report focuses on macro-level actions that the University, College, and CCUR must take to ensure that a more robust economic development environment is constructed at ISU. Table ES-2 outlines recommended strategies and actions to help position CCUR and ISU as active players in Iowa's agbioscience economy. These specific actions and investments will enhance the College of Agriculture's and CCUR's impact on agbioscience-based economic development. Implementation of these strategies and actions is anticipated over a 5-year period. Immediate priorities should be undertaken in the next year, mid-term priorities in 1 to 3 years, and long-term priorities in 3 to 5 years.

Table ES-2. Recommended Strategies and Actions

CCUR-Centric Initiatives		
Strategies	Actions	Time Frame
Enhance Funding and Staff Resources for CCUR	▪ Increase operational funding for hiring key staff positions to focus on key economic development and commercialization activities	Mid-Term
	▪ Develop proof-of-concept (gap) funding for pre-commercialization research	Mid-Term
	▪ Catalyze pre-seed handoff for follow-on funding	Mid-Term
Build Strategic Relationships with the Agbioscience Industrial Base	▪ Build relationships with four large strategic partners each in the food and bioeconomy applications	Immediate
	▪ Serve as a catalyst for developing strategic partnerships with Iowa companies	Mid-Term
	▪ Continue support and expansion of CCUR's prototyping facilities	Mid-Term
Aggressively Market CCUR's Capabilities to Industry	▪ Create associate directors responsible for building awareness in each of their focus areas	Long-Term
	▪ Increase marketing and communications with industry	Immediate
University- and College-Level Initiatives		
Focus Economic Development Efforts on Major Strategic Initiatives	▪ Building on work already underway in the Office of the Vice Provost for Research, create an ISU Directorate for Economic Development at the Presidential Cabinet level to elevate ISU's commitment to economic development	Immediate
	▪ Align University and Directorate goals with priorities of IDED technology development platforms	Immediate
	▪ Prioritize vertically integrated strategic projects	Immediate
	▪ Develop a University communications program focusing on ISU's commitment to industrial partnerships and knowledge transfer activities	Mid-Term
Develop a Culture of Commercial Engagement	▪ Develop faculty reward system for innovation, commercial engagement, and entrepreneurship	Mid-Term
	▪ Develop and coordinate commercialization and entrepreneurship assistance programs	Mid-Term
	▪ Establish relationships with leading industry representatives in key agbioscience industry sectors	Mid-Term

CONCLUSION

Universities are important contributors to technology-based economy development. They not only generate new discoveries, but also provide the talent needed to drive a technology-based economy. Yet, it must be recognized that promoting economic development is not the primary role of universities. Their primary roles are to educate students and produce new knowledge. Efforts to leverage universities to build technology-based economies must recognize and respect this. At the same time, involving universities in technology-based economic development can help ensure that discoveries are used to better people's lives. It can also provide real-world experiences for faculty and students alike.

CCUR and ISU have tremendous assets upon which to build an agbioscience-based economy in the State of Iowa; but, in turn, it also has some significant barriers to overcome to create the knowledge transfer capacity that will enable Iowa to reap the dividends from the intellectual resources within ISU's research base. Many academic and research institutions, in the United States and overseas, have placed an emphasis on economic development, commercialization, and entrepreneurship activities. These institutions have found ways to offset barriers and impediments and translate their research and innovation into firms or products with commercial potential and new business growth. Several of these highly active institutions are pursuing development opportunities in agbioscience and related fields, and much can be learned from their experiences. However, at the same time, they represent a significant source of competition for CCUR and ISU. Therefore, it is imperative that CCUR and ISU focus its attention and resources to developing the programs and systems that will help ensure that it contributes toward making higher education an economic engine for the State of Iowa in agbioscience-based economic development.