



Bioscience & Innovation

Identifying and Strengthening Our
Bioscience Assets and Opportunities

Table of Contents

1 – Conveyance of Road Map and Acknowledgements	4
2 - Project and Report Overview	5
3 - Executive Summary and Recommendations	7
3.1 – Bioscience Definition and Competitive Landscape	7
3.2 – Methodology and Approach	8
3.3 – Summary of Qualitative and Quantitative Data.....	9
3.4 - Summary of Findings	10
3.5 – Hot Team Targets of Opportunity.....	10
3.6 – Summary of Recommendations	11
3.7 – Implementation Timeframe	12
4 – Bioscience Definition.....	13
4.1 – Kansas Bioscience Snapshot.....	14
4.2 - The Competitive Landscape	15
5 – Assessment Methodology and Approach.....	20
6 – Qualitative and Quantitative Data.....	23
6.1 – Qualitative Data - Survey.....	23
6.2 – Qualitative Data - Regional Summits	25
6.3 – Quantitative Data - Federal R&D Funding	26
6.4 – Quantitative Data – Patents.....	32
6.5 – Quantitative Data – Venture Capital Investment	35
6.6 – Quantitative Data – Workforce Composition	36
6.7 – Academic R&D and Science and Engineering Degree Production	39
7 – Findings.....	41
7.1 - SWOT (Strengths/Weaknesses/Opportunities/Threats) Analysis	41
7.2 – Cross-cutting Business and Innovation Environment Issues	42
8 – Hot Team Targets of Opportunity Profiles	44
8.1 – Advanced Materials and Medical Devices	45
8.2 – Animal Sciences.....	47
8.3 – Biomass, Biofuels, Biomaterials and Environmental Applications.....	48
8.4 – Drug Discovery, Delivery and Pharmacogenomics.....	49
8.5 – Health Related IT (including Bioinformatics and Telemedicine/Telehealth).....	50
8.6 – Plant Sciences	51
9 – Recommendations.....	52
9.1 - Big Ideas for Global Competitiveness:.....	53
9.2 - Fundamental Actions/Enabling Factor:	61
9.3 - Other Opportunities for Further Consideration:	63
10 – Conclusion	64
10.1 - Hot Team Implementation Timeline and Critical Next Steps:	64
10.2 – Closing: The Imperative to Implement	65

Table of Figures

Figure 1 - Three Phase Road Map Implementation Process	8
Figure 2 - World Leaders in Biotechnology are already Realizing Economic Gains	15
Figure 3 – Inter-connected Hubs and Nodes.....	19
Figure 4 - Hot Team Process	21
Figure 5 – The Innovation Lifecycle®	22
Figure 6 - 1993 – 2002 Federal Funding to Kansas, by Performer Type	27
Figure 7 - 1993 – 2002 Unrestricted Federal Funding to Kansas by Agency.....	28
Figure 8 - 1993 – 2002 Unrestricted SBIR/STTR Funding to Kansas by Technology Sector.....	30
Figure 9 - Growth in Patenting, US and Kansas, 1990 - 2002.....	32
Figure 10 – Patent Totals and Growth by Region.....	32
Figure 11 - Statewide Patent Totals and Growth by Technology Category	33
Figure 12 – Kansas Bioscience Occupational Analysis.....	36
Figure 13 - Annual Growth Rate in Biotech-related Technical Occupations, 2000-2002	38

Table of Tables

Table 1 - Snapshot of Kansas Innovation Economy	8
Table 2 – Data Collection for the Kansas Bioscience and Innovation Road Map.....	9
Table 3 - Hot Team Target of Opportunity Profiles	10
Table 4 - Kansas Road Map Recommendations: Big Ideas and Fundamental Actions.....	11
Table 5 - Hot Team Implementation Timeline	12
Table 6 - NAICS Codes from the Kansas Economic Growth Act (as ammended)	13
Table 7 - Kansas Bioscience Snapshot: Establishments, Employment, & Wages, 2002	14
Table 8 - Key Biosciences Trends and Cluster Implications	17
Table 9 – Aggregate and Personal Economic Indicators, Kansas and Competitors, 2003	18
Table 10 - Survey Respondents’ Satisfaction with Business Climate Factors in Kansas.....	23
Table 11 - Locations and Dates of Regional Bioscience and Innovation Summits.....	25
Table 12 - Research and Development Statistics, Kansas and Competitor States, 2002	26
Table 13 - Industry R&D in Kansas and Competitor States, 2002	27
Table 14 - Number of SBIR awards, 1999-2002	30
Table 15 - Overview of Federal Funding at Kansas Universities and Colleges	31
Table 16 - Venture Capital Activity by Industry, Kansas and the US, 1995 - 2003	35
Table 17 – Kansas Employment and Wages in Key Occupations	37
Table 18 - Biotech-Related Occupations and their Projected 10 Year Growth	38
Table 19 - Academic and Public Sector Expenditures on Higher Education	39
Table 20 – Science & Engineering PhDs Awarded in Kansas and Competitor States, 2002	39
Table 21 - Number of Universities and Colleges Receiving Federal R&D Funding vs. Total Number of Such Institutions in State, FY 2002	40
Table 22 - SWOT Analysis.....	41
Table 23 - Hot Team Target of Opportunity Profiles	44
Table 24 – US Medical Device Industry Market Size by Specialty (as of October 24, 2003)	46
Table 25 - Kansas Road Map Recommendations: Big Ideas and Fundamental Actions.....	52
Table 26 - Hot Team Implementation Timeline	64

1 – Conveyance of Road Map and Acknowledgements

May 16, 2005

Memorandum to Road Map Steering Committee
From Richard Seline, CEO and Principal, New Economy Strategies, LLC
Re: Conveyance of Road Map and Acknowledgements

The following 2004-2005 *Kansas Bioscience and Innovation Road Map* was based on the engagement of nearly 500 Kansans in the creation of a competitive scenario and the positioning of Kansas as a global hub in human, animal, plant and medical device-related economic sectors.

The citizens of Kansas will find herein the counsel and guidance from the best minds and experts across disciplines and geography. The result is a Road Map whose scope is broad, and whose relevance is not limited to any one organization or institution, either in the academic or industry arenas. We encourage the readers of the Road Map to consider the context in which the plans outlined throughout this document will be developed and implemented, specifically:

- The state of Kansas has benefited from the vital mechanisms for strategic thinking and execution such as KTEC – an entity that has become a national best practice model,
- The state of Kansas and its legislative members have had the foresight to form and fund the *BioAuthority* through the Kansas Economic Growth Act, allowing for specific tactics to receive the necessary resources for appropriate launch and operation, and
- The state of Kansas continues to view its asset base as a function of geographically distributed unique and distinguished academic research institutions that require an atmosphere of integration, leverage and collaboration.

Kansans are fortunate to have existing organizational mechanisms in place to convert public investments into economic and societal benefits. While many other states and nations are just now organizing themselves to compete in the biosciences, Kansas is already well-positioned to use the Road Map as a balanced portfolio of actions for immediate implementation.

The frank assessment of Kansas' strengths, weaknesses, opportunities, and threats and the identification of critical priorities contained in the Road Map are powerful tools which can help Kansas build on the success of previous efforts by its executive, legislative, and civic leadership to catalyze its competitiveness.

This report would not have been possible without the significant contributions of many dedicated individuals and groups. The contributors to this report were too numerous to mention by name, but they can rest assured that they have earned our most sincere gratitude. We would especially like to thank the leadership and team members at the Kansas Technology Enterprise Corporation (KTEC), which sponsored the Kansas Bioscience and Innovation Road Map, as well as the Road Map Steering Committee, and the Road Map's supporting organizations: The Kansas Bioscience Organization (KansasBio), the Kansas Department of Commerce, the National Institute for Strategic Technology Acquisition and Commercialization (NISTAC).

Most importantly, our very special thanks go to the co-chairs, shepherds, and members of the six Hot Teams, as well as the Bioscience and Innovation Road Map survey and summit participants. These 500 individuals are the real 'architects and engineers' of the Bioscience and Innovation Road Map!

2 - Project and Report Overview

To facilitate the process of understanding Kansas' bioscience assets and opportunities, the Kansas Technology Enterprise Corporation (KTEC) engaged New Economy Strategies (NES), a Washington, DC based consultancy, to develop a comprehensive Road Map that provides strategic guidance to the state's bioscience initiative. Joining KTEC in supporting the *Kansas Bioscience and Innovation Road Map* initiative are the Kansas Bioscience Organization (KansasBio), the Kansas Department of Commerce, and the National Institute for Strategic Technology Acquisition and Commercialization (NISTAC).

The *Kansas Bioscience and Innovation Road Map* focused on achieving three objectives:

- Identify the bioscience and innovation assets of Kansas;
- Galvanize the statewide leadership needed to catalyze growth in targeted bioscience clusters; and
- Make long- and short-term recommendations for achieving national and international competitiveness in the bioscience arena.

NES worked with regional and state leaders to research Kansas' capacities to compete, innovate, and perform around current and emerging biotechnology and technology clusters. The focus was on creating economic '**churn**' through **innovation**.

Churn: Sustainable, consistent adaptation and evolution over the course of the business stages of the Innovation Lifecycle® (conception, formation, growth and maturity). Churn is the ability of a region's economic, scientific, technological and entrepreneurial resources to continually and collaboratively produce new ideas and new enterprises.

Innovation: A social process that brings together and aligns a variety of institutions, industries, and individuals to create new products, services, and ultimately new ways of competing in the global marketplace.

Key elements of the *Kansas Bioscience and Innovation Road Map* process included the following:

- Collecting and analyzing data that build the business case and value proposition for the Targets of Opportunity;
- Benchmarking new approaches and focused technology trends;
- Facilitating six *Regional Bioscience and Innovation Summits* with key business, academic, government leaders and other critical stakeholders to present preliminary findings, identifying bioscience priorities, and determining critical focus areas;
- Identifying target areas of opportunity in existing science and technology competencies, emerging sectors, and traditional industries;
- Determining overarching tactics focused on cluster-specific needs (e.g., skills training, new enterprise development incentives) and cross-cluster issues (e.g., transportation, regulations, workforce development);

- Forming Hot Teams comprised of academic, industry, government, and other state and regional stakeholders to craft initiatives and related business plans to address each target of opportunity.

Key Players in the *Kansas Bioscience and Innovation Road Map* process included the following:

- **Sponsoring Organization:** **The Kansas Technology Enterprise Corporation (KTEC)** is a private/public partnership established by Kansas to promote technology based economic development. KTEC assists Kansas entrepreneurs and technology companies by supporting the development and commercialization of new technologies through a statewide network designed and built to support researchers, entrepreneurs, and technology companies through each phase of the technology life cycle. As a natural extension of its mission to support technology-based economic development in Kansas, KTEC leveraged its expertise and resources to play a key role in developing the statewide Bioscience Initiative within the Kansas Economic Growth Act. KTEC sponsored the Kansas Bioscience & Innovation Road Map process.
- **Partner Organization:** **New Economy Strategies (NES)** is a national consulting firm based in Washington, D.C. with a proven track record for developing and implementing technology-based economic development strategies. NES was engaged by KTEC to develop the *Kansas Bioscience and Innovation Road Map*. NES' previous work includes producing *The Greater Kansas City Health Care Innovation Scenario: A Road Map for Life Sciences & Convergent Technologies* in June, 2004 for the **Kansas City Area Life Science Institute (KCALSI)** and **KCCatalyst**.
- **Supporting Organization:** **The Kansas Bioscience Organization (KansasBio)** is a not-for-profit organization serving as a unified voice representing the bioscience community in Kansas. Across the human, plant, animal and industrial biosciences, KansasBio is focused on enhancing the business and research climate and working with leaders across the state to attract and retain bioscience talent, companies and funding. KansasBio was founded in 2004 by the Kansas Technology Enterprise Corporation (KTEC) and the Kansas City Area Life Sciences Institute (KCALSI).
- **Supporting Organization:** **The Kansas Department of Commerce** empowers businesses and communities through bold leadership using strategic resources to realize prosperity in Kansas. As key agency for economic development in Kansas, the Department of Commerce's responsibilities are to foster economic development through the promotion of business, commerce, and industry.
- **Supporting Organization:** **The National Institute for Strategic Technology Acquisition and Commercialization (NISTAC)** is a not-for-profit innovation commercialization center that was developed as a partnership between KTEC and Kansas State University. Its state mission is to provide business incubation services, pre-seed capital and technology transfer support activities for individual entrepreneurs in the region and to commercialize intellectual property emanating from basic research at Kansas State University. NISTAC has established an impressive track record of creating significant numbers of jobs in the regional economy (with annual salaries averaging approximately \$42,000), licensing intellectual property from Kansas State University and creating start-up companies leveraging over \$26 million of external resources over the past seven years.

3 - Executive Summary and Recommendations

3.1 – Bioscience Definition and Competitive Landscape

The complex construct of the biosciences community does not allow for an easy examination of its segments and applications, as they are often inter-related, overlapping and/or newly emerging. The increasing use of collaborative efforts among various entities along the supply and value chains as well as the convergence opportunities offered by the pervasive thread of technological advances makes the task a complicated one. Our definition of the biosciences seeks to include a broad platform of technological and scientific reach – including plant and animal production, medical devices, bioinformatics, and health care management.

Elements of the Bioscience Industry:

Primary: Human, Animal, Plant, Industrial/Environmental

Secondary: Pharmaceuticals, Life Sciences, Plant-made Pharmaceuticals, Nutraceuticals, Plant Sciences, Agri-biotechnology, Bio-materials, Homeland Security, Environmental Remediation, Bio-fuels, Veterinary Medicine, Medical Devices, (Instruments, Supplies, and Diagnostic Equipment), Biotech Drugs, and Therapeutics.

Competitive Landscape:

Kansas faces competition not just from other US states and regions, but from across the globe. Advanced nations with long histories of scientific excellence such as England, France, and Germany are well-established global competitors. Additionally, serious competitive pressures are also being brought to bear by rising stars such as Brazil, Singapore, Taiwan, India, and China who are investing heavily in their human capital and innovation infrastructure.

The possibilities for growth in the new economy are virtually unlimited. Bioscience is such a vast, complex, and still largely uncharted frontier, that it is not possible for any one state, country or region to be the authoritative leader in all of its aspects. Any area in the world is free to develop its own niche expertise, based on the unique assets that it brings to the table. Therefore, if Kansas has the vision, and is able to coordinate the resources, both internal and external, it can create the necessary critical mass of innovation and become a serious global contender. The other side of this coin, however, is that the potential competition in the bioscience economy is also virtually unlimited.

Existing Innovation Expertise and Assets:

Kansas is well-positioned to become a bioscience leader in specific areas, both due to its existing expertise in many of the various elements of the bioscience economy (human health, animal and plant sciences, biomaterials, military/homeland security, pharmaceuticals and drug discovery, and information and computer technology), and due to its existing assets (a skilled workforce,

high quality research and education institutions, clusters of high technology companies, etc.). Table 1 highlights some important components of Kansas’ innovation economy, as well as how Kansas ranks nationally in those categories.

Table 1 - Snapshot of Kansas Innovation Economyⁱ

Indicators	Kansas Totals	National Rank
Total Gross State Product (millions of \$)	\$93,352	31
<i>Per Capita</i> Personal Income, 2003	\$29,438	28
S&E Doctorates Awarded, 2002	275	28
Population, 2003 (thousands)	2,724	34
Federal R&D Obligations, 2002 (millions of \$)	\$291	38
Total R&D Performances, 2002 (millions of \$)	\$1,865	28
Industry R&D, 2002 (millions of \$)	\$1,427	24
Academic R&D, 2002 (millions of \$)	\$300	31
% of Academic R&D Invested in Life Sciences	64%	unknown
Academic R&D Invested in Life Sciences (millions of \$)	\$192	unknown
Public Higher Education Current-Fund Expenditures, 2001 (millions of \$)	\$1,831	32
Number of SBIR Awards, 1999-2002	71	34

3.2 – Methodology and Approach

The data collection and the analysis of Kansas’ bioscience competencies followed a three phase process (detailed in Figure 1 below). The three phases were 1.) Collecting data and mapping existing assets, 2.) Identifying opportunities on which to target time and efforts to design the Road Map, and 3.) Finding the means to launch a sustainable implementation effort driven by partnerships between academia, industry, and government.

Figure 1 - Three Phase Road Map Implementation Processⁱⁱ



NES recently had the opportunity in June of 2004 to produce *The Greater Kansas City Health Care Innovation Scenario: A Road Map for Life Sciences & Convergent Technologies* with the Kansas City Area Life Science Institute (KCALSI). The knowledge and experience gained from working on this prior report were a distinct advantage for NES when it was asked to produce this current statewide assessment. However, by no means does any part of this current *Kansas Bioscience and Innovation Road Map* represent a duplication whatsoever of any previous work for the KCALSI. Additionally, NES benefited from the high-quality work produced by the Lawrence Bioscience Initiative.

3.3 – Summary of Qualitative and Quantitative Data

Table 2 briefly outlines the different pieces of quantitative and qualitative data collected during the Road Map process that helped drive the findings and recommendations.

Table 2 – Data Collection for the Kansas Bioscience and Innovation Road Map

Source	Description	Intended Outcome
Quantitative Data		
Competitive Benchmarking	Comprehensive market assessment / competitor analysis on a domestic and global scale of the trends for the various targets of opportunities	Identify strategies, tactics and approaches for implementation
Industry/ Workforce Analysis	Gather comprehensive data by specific bioscience industry and sector, including employment, wage and output data from Economy.com	Build the fundamentals of the regional clusters and determine the regional, national and global economic trends within key sectors impacting the current and future direction of Kansas
RAND RaDiUS	Database that tracks all federal dollars awarded in science and technology to public and private entities	Identify research areas with current or potential for generating substantial federal support & funding as well as commercialization
Patent Research by 1790 Analytics, LLC	Provides unique access to academic papers and patents	Determine critical outcomes from research application and precursors of potential commercialization
MoneyTree Survey	The definitive source of information on emerging companies that receive financing and the venture capital firms that provide it	Provides venture capital investment activity, both for Kansas and for the US, by high – tech industry, 1995 - 2003
Academic R&D and S&E Degree Production	Survey of Federal and overall academic R&D funding and educational resources in Kansas and competitor states	Number of PhDs in science and engineering (S&E) and Academic R&D funding, particularly in Life Sciences. Per capita public higher education spending. Number of degree-granting institutions.
Qualitative Data		
Regional Summits	Kansas stakeholders and leaders attended six summits held throughout the state from October 4 th - 7 th , 2004.	Participants shared preliminary findings, generated feedback on initial recommendations, and discussed future actions
Regional Mindset Survey	Electronic survey distributed to more than 1,000 community and business leaders containing questions surrounding innovation, the economy, and perceptions about the region.	Acquire a set of key action steps and recommendations for accelerating the competitiveness of Kansas and assess current attitudes about the state's ability to compete

3.4 - Summary of Findings

The work of the Hot Teams complimented and magnified the results of the quantitative and qualitative data gathered during the Road Map process. When all of the separate elements were brought together, a clear and compelling picture of Kansas' assets began to emerge. Thanks in particular to the work of the Hot Teams and to the input gathered from the survey and forum participants, it was possible to identify Kansas' primary strengths and weaknesses, as well as the opportunities and threats it faces in the future. The many underlying strengths inherent to Kansas include a highly-educated and productive labor force, a high quality of life, world-class educational institutions, and generations of expertise in key areas such as animal and plant sciences and biomaterials and biofuels. The most promising opportunities lie in areas where Kansas can leverage existing competencies, such as in human and animal health, agriculture, and information technology. Weaknesses include a lack of venture capital funding, inadequate levels of federal funding, and the lack of a coordinated pipeline to provide Kansas' businesses with the knowledge workers of the future. Threats facing Kansas include human capital flight (*e.g.* "Brain Drain"), increased global competition, and the risk of being perceived negatively outside the state, or simply overlooked, in the absence of a coordinated branding and positioning effort.

3.5 – Hot Team Targets of Opportunity

Based on the quantitative and qualitative findings, six Targets of Opportunity (areas of high potential) were identified. Accordingly, six groups of industry, academic, and civic leaders were formed into Hot Teams to evaluate the existing assets and competencies in these areas, and to determine Kansas' ability to exploit these opportunities to compete in the global marketplace. The Hot Teams were composed of individuals from diverse backgrounds united by their common commitment to finding solutions to the challenges facing Kansas. The six Targets of Opportunity around which the Hot Teams were formed are outlined in Table 3.

Table 3 - Hot Team Target of Opportunity Profiles

Hot Team	Description
Advanced Materials & Medical Devices	Advanced materials are a critical key to technological advancements in a number of industries. The medical device and diagnostics industry produces equipment designed to aid medical therapies.
Animal Sciences	Animal Science is the field of study involving the production, marketing, and utilization of domestic animals in agriculture, entertainment, and companionship.
Biomass, Biofuels, Biomaterials, & Other Environmental Applications	Biomass, biofuels, biomaterials, and other environmental applications represent a subset of the myriad of applications of advanced biological sciences research.
Drug Discovery, Delivery, and Pharmacogenomics	Drug discovery and development includes target discovery and identification, lead discovery and identification, drug metabolism and toxicity, drug process and development, and application of genomics, proteomics, pharmacogenomics and bioinformatics in accelerating drug discovery and development.
Health-Related IT (including Bioinformatics and Telemedicine)	Bioinformatics is the convergence of computer science, information technology and biotechnology. Telemedicine is the use of telecommunication to provide diagnostic and therapeutic medical information between a patient and doctor without either of them having to travel.
Plant Sciences	Plant Science is the field of study involving the production, marketing, utilization and study of plants and plant materials.

3.6 – Summary of Recommendations

During the three month Hot Team process, the six Hot Teams discussed more than forty distinct ideas, and developed detailed business plans outlining the best of these proposals. Because of the considerable synergies existing between the proposals, it was possible to synthesize the key elements of the business plans into four “Big Ideas,” four “Fundamental Actions,” and one “Enabling Factor” (the “Statewide Collaboratory”), an umbrella piece which connects them all. Combining the plans into a discreet number of initiatives allows Kansas to effectively leverage its resources and concentrate its efforts on the most critical actions. It is worth noting that none of the “Big Ideas” or “Fundamental Actions” developed from the efforts of one single Hot Team, and each of the six Hot Teams made fundamental contributions to at least one of the “Big Ideas.” Rather, it was the strong cooperation between teams, which allowed the synergies to develop. Table 4 below outlines the “Big Ideas” and the “Fundamental Actions,” and which Hot Teams contributed to which recommendations.

Table 4 - Kansas Road Map Recommendations: Big Ideas and Fundamental Actions

	Initiative	Hot Team Contributions
Big Ideas	1.) Kansas Institute for Comparative Health (including <i>Statewide Telemedicine Delivery</i> and a <i>Statewide Cancer and Oncology Strategy</i>)	- Drug Discovery - Health-related IT
	2.) Fusion Center for Animal Health and Food Safety (including <i>Monitoring and Managing Biological Risk</i>)	- Animal Sciences - Health-related IT
	3.) Kansas Center for Biologically-Inspired Materials	- Advanced Materials - Biomass & Biofuels - Plant Science
	4.) Kansas Bioproducts Initiative (including the <i>Statewide Biofuels Project</i> and the <i>Neutraceuticals Project</i>)	- Plant Science - Biomass & Biofuels
Fundamental Actions	1.) The Statewide Workforce Continuum: <i>Developing Skills, Competencies and Future Talent</i>	All Hot Teams
	2.) Awareness Campaign: <i>Positioning Kansas’ Assets</i>	All Hot Teams
	3.) Statewide Funding Team: <i>Gathering Resources for Competitiveness</i>	All Hot Teams
	4.) 3C: <i>Catalyzing Capital, Commercialization & Critical Mass of Growth, Mature Companies</i>	All Hot Teams
Enabling Factor	Statewide Collaboratory: <i>Accelerating Digital BioScience Connectivity</i>	- Health-related IT - Drug Discovery

3.7 – Implementation Timeframe

Table 5 below outlines some of the most important next steps and milestones for the immediate-term, near-term, and long-term implementation of the “Big Ideas,” “Fundamental Actions,” and “Enabling Factor.”

Table 5 - Hot Team Implementation Timeline

Immediate (0-18 months)	Near-term (18-36 months)	Long-term (36+ months)
Big Idea #1: Kansas Institute for Comparative Health (including <i>Statewide Telemedicine Delivery and a Statewide Cancer and Oncology Strategy</i>)		
Inventory assets along disease categories. Partnering within the Institute.	Recruitment of global partners. Identification of priorities for test-bed, pilots.	Production, spin-off, commercialization of new product. 100% utilization rate by service providers, end-users, deployment
Big Idea #2: Fusion Center for Animal Health and Food Safety (including <i>Monitoring and Managing Biological Risk</i>)		
Recognition by in-state and global research partners. Partnering within the Fusion Center.	Launch of Center sub-category programs. Identification of priorities for test-bed, pilots.	Attraction of global food safety collaboratory, implementation of a warning system. 100% utilization rate by service providers, end-users, deployment.
Big Idea #3: Kansas Center for Biologically-Inspired Materials		
Attention to 2-3 specific products, markets	Creation of product development ‘teams’	Recognition as the location for innovation, creative materials. Proven commercialization results.
Big Idea #4: Kansas Bioproducts Initiative Statewide (including the <i>Statewide Biofuels Project and the Nutraceuticals Project</i>)		
Establish prioritized agenda of market analysis, targets. Form Biofuels Working Group and Nutraceuticals Working Group	Recruit industry market product teams. Position Biofuels and Nutraceuticals projects as national agenda-setters	Initiate Commercialization process in enterprise development stage, create new biofuels and nutraceuticals companies.
Fundamental Action #1: The Statewide Workforce Continuum		
Organize Continuum ‘Hot Team’ among key providers	State, federal, industry funding successfully captured	Successful realignment of education, training, provider, and end-user networks
Fundamental Action #2: Awareness Campaign		
Coordinate and prioritize the awareness agenda	Create and launch awareness campaign, establish performance metrics	Take advantage of increased visibility and positive image to foster increased growth, new company creation
Fundamental Action #3: Statewide Funding Team		
Inventory top funding priorities from implementation agenda	Create and launch Funding Team	Promote Kansas moving from EPSCOR to New Ranking
Fundamental Action #4: 3C: Catalyzing Capital, Commercialization & Critical Mass of Growth, Mature Companies		
Implementation of legislative agenda for the commercialization focus	Attraction of industry and entrepreneurial risk-taking new dollars, skills	Completion of \$100 million in startup, growth and mature stages of investment
Enabling Factor: Statewide Collaboratory		
Enshrine electronic infrastructure created from the Hot Team process. Devise mechanism to encourage principal investigators to share knowledge, incentivize cooperation.	Develop structure and methodology for matching grant management/co-investments, secure funding. Assist with branding and positioning efforts.	Facilitate the formation of lasting partnerships between industry, principal investigators, academia, and government. Position the collaboratory as a clearinghouse for research and intellectual property.

4 – Bioscience Definition

Bioscience Definition from the Kansas Economic Growth Act (as amended):ⁱⁱⁱ

“Bioscience” means the use of compositions, methods and organisms in cellular and molecular research, development and manufacturing processes for such diverse areas as pharmaceuticals, medical therapeutics, medical diagnostics, medical devices, medical instruments, biochemistry, microbiology, veterinary medicine, plant biology, agriculture and industrial, environmental, and homeland security applications of bioscience, and future developments in the biosciences. Bioscience includes biotechnology and life sciences.

“Bioscience company” means a corporation, limited liability company, S-corporation, partnership, registered limited liability partnership, foundation, association, nonprofit entity, sole proprietorship, business trust, person, group, or other entity that is engaged in the business of bioscience in the state and has business operations in the state, including, without limitation, research, development, sales, services, distribution or production directed towards developing or providing bioscience products or processes for specific commercial or public purposes but shall not include entities engaged in the distribution or retail sale of pharmaceuticals or other bioscience products... One of the factors that shall be considered is whether a company has been identified by the department of labor by one of the following NAICS codes: 325411, 325412, 325413, 325414, 325193, 325199, 325311, 325320, 334516, 339111, 339112, 339113, 334510, 334517, 339115, 621511, 621512, 541710, 541380, 541940, and 622110.

Table 6 - NAICS Codes from the Kansas Economic Growth Act (as amended)^{iv}

NAICS Code	NAICS Title
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
325414	Biological Product (except Diagnostic) Manufacturing
325193	Ethyl Alcohol Manufacturing
325199	All Other Basic Organic Chemical Manufacturing
325311	Nitrogenous Fertilizer Manufacturing
325320	Pesticide and Other Agricultural Chemical Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
339111	Laboratory Apparatus and Furniture Manufacturing
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334517	Irradiation Apparatus Manufacturing
339115	Ophthalmic Goods Manufacturing
621511	Medical Laboratories
621512	Diagnostic Imaging Centers
541710	Research and Development in the Physical, Engineering, and Life Sciences
541380	Testing Laboratories
541940	Veterinary Services
622110	General Medical and Surgical Hospitals

4.1 – Kansas Bioscience Snapshot

Our best estimates compiled from Kansas Department of Labor data indicate that there are approximately 70,000 employees in 1,200 companies and universities engaged in the business of bioscience in Kansas. 55,000 employees and 650 companies are involved in the provision of healthcare and other bioscience-related services in hospitals and veterinary clinics, and approximately 5,000 university employees work in departments related to the biosciences. In non-services private sector organizations, there are approximately 10,000 employees working for 550 companies in the biosciences.

Excluding bioscience services and university activities, the largest bioscience-related sub sector in Kansas is the agricultural feedstock and chemicals sector, which accounts for about 38% of Kansas bioscience businesses and 43% of Kansas bioscience employment. Next is the medical devices and equipment sector, accounting for about 32% of businesses and 28% of employment. The pharmaceutical sector accounts for about 12% of businesses and 24% of employment. Companies involved primarily in research and testing represent 19% of total bioscience businesses, but only 6% of total bioscience employment. According to estimates by the Association of University Technology Managers and Ernst & Young, over the next ten years, Kansas could see the creation of more than 100 new bioscience companies and more than 23,000 new bioscience jobs.^v

The average annual wage across the sub sectors of the Kansas bioscience industry shown in Table 7 below was \$41,760 in 2002, only two thirds (66.5%) the national average of \$62,845, but significantly higher than the overall average annual wage in Kansas, which was \$30,825 in 2002.^{vi} Although the cost of living in most parts of Kansas is lower than the national average, the difference in cost of living is estimated at being no more than 5-10%, which does not fully compensate for the difference in wages. However, there is evidence that wages in Kansas' overall economy are rising faster than the national average (see Table 17 on p. 35).

Table 7 - Kansas Bioscience Snapshot: Establishments, Employment, & Wages, 2002 ^{vii}

Industry Sub sector →	Agricultural Feedstock & Chemicals		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research & Testing	
	↓ Metric ↓	KS	US	KS	US	KS	US	KS
2002 Establishments	69	3,353	21	2,536	57	6,120	34	5,149
2001 - 2002 Establishment % Change	0.3%	-0.9%	-8.7%	0.7%	-1.0%	-0.1%	-6.2%	-2.0%
2002 Employment	1,975	156,759	1,100	293,179	1,299	326,201	255	116,733
2001 - 2002 Employment % Change	-3.7%	-5.6%	8.2%	4.5%	-3.6%	-1.3%	11.4%	0.1%
Share of US Employment	1.3%	100%	0.4%	100%	.04%	100%	0.2%	100%
2002 Average Wage	\$43,958	\$55,919	\$44,999	\$73,162	\$35,628	\$53,939	\$41,999	\$71,118

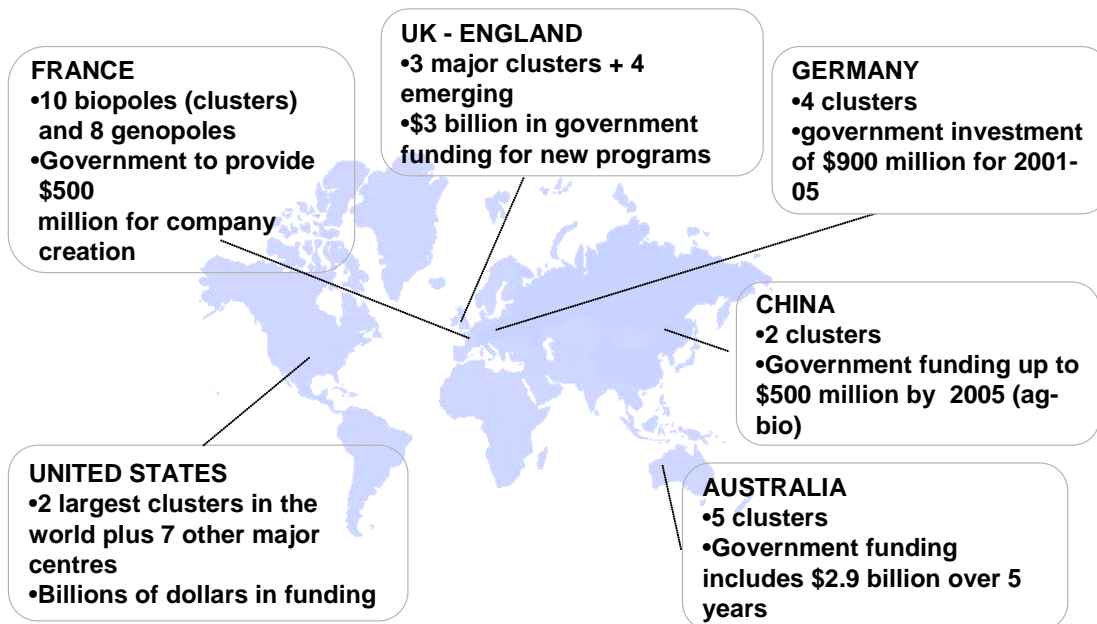
4.2 - The Competitive Landscape

As the baby boomer generation continues to age, the emphasis placed on healthcare and its various facets continues to grow. Developments in research labs across the world have allowed the population to enjoy increasingly longer life expectancies. Despite these breakthroughs, the cure for many life-threatening diseases remains elusive and the cost of healthcare continues to rise at an alarming rate. However, solutions emerging through biotechnological developments and discoveries can help to reduce these costs, increase productivity and enhance overall patient care. Savings – in the trillions – could be realized with the production of life-saving treatments and drugs to both prevent and cure diseases such as heart disease.

As technology and innovation continue to drive developments and change paradigms across all aspects of our lives, so too does it result in a shift in the healthcare industry’s approach to preventive treatment of these diseases. Using biosciences, researchers are attempting to use gene therapy and other revolutionary treatments to combat these omnipresent diseases. Significant attention and dollars are devoted to bio-related research, which represents a huge opportunity for regions with the critical mass to support a thriving biosciences cluster.

Global Perspective:

Figure 2 - World Leaders in Biotechnology are already Realizing Economic Gains ^{viii}



Source: New Economy Strategies, 2003; The Brookings Institution Center on Urban and Metropolitan Policy, 2002

Some 40 regions in the United States and approximately 17 elsewhere around the world are racing to develop the next generation of biosciences clusters. From Singapore to Australia in the

Asia-Pacific, from Saskatoon to Toronto in Canada, and from Cambridge to Paris in Europe, global competitors are emerging in specific biosciences arenas.

Formation of a statewide strategy must take into account the realities of a global marketplace – research and development generally occurs in several countries before reaching the marketplace. Ireland and Scotland alone are home to more than 50 major pharmaceutical outsourcing facilities, while Mexico has over 100 production and manufacturing facilities. Nearly all of the largest U.S. companies have facilities distributed throughout the world and do most of the production outside of the country. More than 60% of major U.S. pharmaceutical companies are now outsourced.

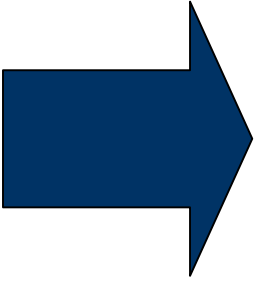
Formation of strategies that seek to attract, recruit, market, and promote Kansas' biosciences requires a global perspective – even though the United States is still the dominant driver of biosciences, the Asian 'tigers' of China, Korea, Taiwan, and Singapore are poised to leapfrog this competitive position within the next eight to 10 years.

National Perspective

In the United States, the formation of biosciences/life science clusters is considered a mandatory strategy of regional and state economic development. Many states have instituted public policies that enhance the environment for growing their clusters. For instance, the New Jersey strategy allows emerging, growth companies to sell their early losses to more established firms – thereby creating a new pool of investment dollars in exchange for favorable consequences against state income taxes. These so-called “carry-forward losses” have increased the number of startups in the New Jersey region. Other state policies include incentives for the relocation of outsourced divisions from global biosciences companies, investment in life-science related infrastructure that hosts newly-commercialized university research, and recruiting highly-regarded research teams. Simply put, if Kansas is to compete in the emerging bioeconomy, it must develop a portfolio approach to its strategies and tactics.

After 25 years of watching the infant biosciences industry mature and the success of vital clusters developed in other industries, regions worldwide are coming up with their own strategies to acquire — and maintain — a major piece of the healthcare industry pie. After several years of constant scanning, dialogue with, and travel around the United States, NES has begun to capture the unique activities and approaches underway to recruit, attract, and retain the scientists and entrepreneurs that form their own biosciences clusters. The data suggests that concentration is occurring in a handful of regions. These states and regions have developed a pipeline of strengths for the creation of targeted chemical compounds and materials leading to new drug discoveries and products.

Table 8 - Key Biosciences Trends and Cluster Implications ^{ix}

Key Biosciences Trends:		Cluster Implications:
<ul style="list-style-type: none"> • Maturing Biotechnology Business Models 		<ul style="list-style-type: none"> • Increasing demand for manufacturing and commercial capabilities
<ul style="list-style-type: none"> • Developing technologies in Life Sciences 		<ul style="list-style-type: none"> • Creation of new opportunity with convergence of IT and biotechnology
<ul style="list-style-type: none"> • Emerging personalized healthcare model 		<ul style="list-style-type: none"> • Need to address global markets to find profitable scale of patient population
<ul style="list-style-type: none"> • Rising cost of healthcare 		<ul style="list-style-type: none"> • Pressure to improve the cost and efficiency of drug development
<ul style="list-style-type: none"> • Change in funding model 		<ul style="list-style-type: none"> • Need for creative capital solutions and understanding of biotechnology model
<ul style="list-style-type: none"> • Changing regulatory environment 		<ul style="list-style-type: none"> • Converging global regulatory standards and emphasis on IP protection
<ul style="list-style-type: none"> • Growing public interest in the ethics of Life Sciences 		<ul style="list-style-type: none"> • Risk of public unwillingness to accept certain technologies and applications
<ul style="list-style-type: none"> • Increasing competition from other regions 		<ul style="list-style-type: none"> • Competition for capital, resources, Intellectual Property
<ul style="list-style-type: none"> • Expanding international scope of Kansas companies 		<ul style="list-style-type: none"> • Opportunity in new global markets

Regions and states are amassing the resources, talent, and capital necessary to advance their commercialization and economic development agendas. Over \$18 billion in new resources has been identified and nearly 22 million square feet in new infrastructure are being developed that will make several U.S. regions strong competitors in certain areas of science and technology. These new dollars include initiatives in recruitment, disease-oriented research, and seed and venture capital formation. The square footage increase includes research and commercialization facilities as well as collaborative space for new enterprise formation.

Several regions such as St. Louis, Pittsburgh, Atlanta, and New York City are organizing significant projects to advance biosciences as a priority in their regional economic agendas. These regions have not acted solely for the benefit of a handful of entrepreneurs and innovators, but instead to enhance the resources and environment for accelerating new discoveries that benefit patient care. While each of these regions has their own characteristics and unique culture, common among them are the mechanisms and leadership in place that facilitate the movement of ideas from lab to market in a constant and smooth progression.

Competitor States:

Fixating on the successes and failures of other states and regions runs the risk of becoming an unhealthy obsession, which does nothing but distract Kansas from its primary goal of becoming a leader, not a follower. Nonetheless, using other states as a frame of reference can be quite useful, if taken in the proper context. Kansas can learn a lot about its competitive position by benchmarking both its current assets and its progress towards its goals against other US states. In so doing, it is useful to look at two groups of competitor states – one group composed of the states, which are recognized as national leaders in the bioscience industry (California, New York, Pennsylvania, Maryland, Texas, and Massachusetts), and one group composed of Kansas’ neighbors (Missouri, Colorado, Oklahoma, and Nebraska).

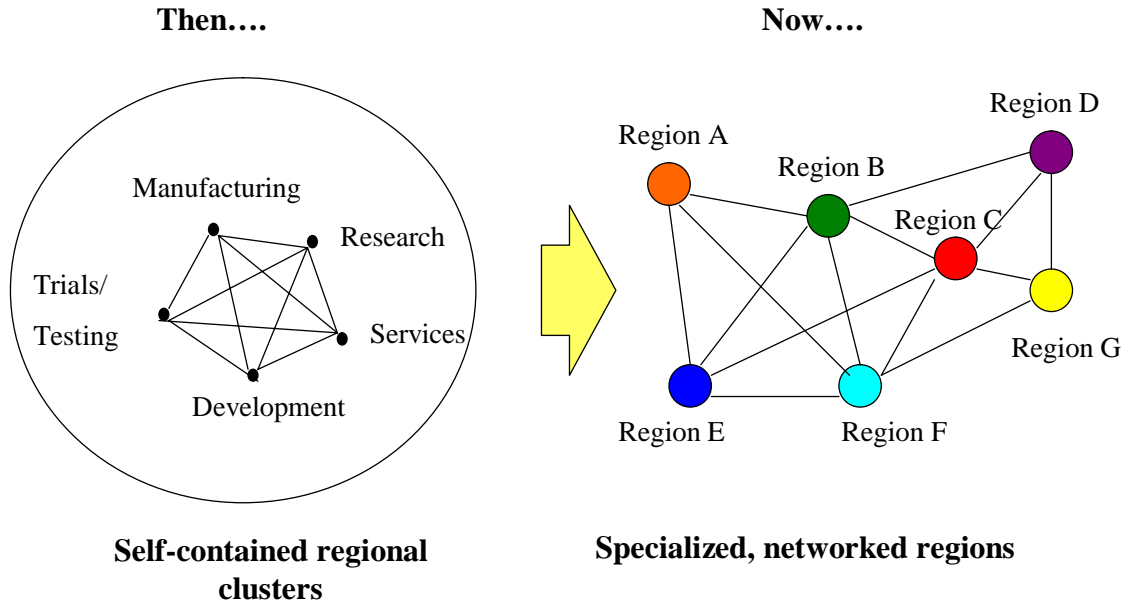
Table 9 – Aggregate and Personal Economic Indicators, Kansas and Competitors, 2003^x

States	Gross State Product (GSP) (millions of \$)	National Rank	GSP <i>per capita</i>	<i>Per Capita</i> Personal Income	National Rank	2003 Population (millions)	National Rank
Leaders	CA	1	\$40,763	\$33,415	12	35.48	1
	NY	2	\$42,817	\$36,112	6	19.19	3
	PA	6	\$36,389	\$31,911	18	12.37	6
	MD	16	\$38,563	\$37,446	5	5.51	19
	TX	3	\$36,761	\$29,074	30	22.12	2
	MA	13	\$46,222	\$39,504	4	6.43	13
Neighbors	MO	20	\$34,118	\$29,464	27	5.70	17
	CO	21	\$41,116	\$34,561	8	4.55	22
	KS	31	\$34,270	\$29,438	28	2.72	34
	OK	30	\$28,583	\$26,719	40	3.51	29
	NE	36	\$37,834	\$30,179	24	1.74	39
US Total	\$10,911,103	N/A	\$37,026	\$31,472	N/A	294.69	N/A

The national leaders provide Kansas with concrete examples of what Kansas can aspire to achieve, as well as useful ‘best practices’. Kansas’ four contiguous neighbors are good states to use as benchmarks for different reasons, and not just because they share a geographical border. Similar geographic locations, geographic sizes and economic and societal histories mean that these states have some of the same natural and comparative advantages as Kansas, and are therefore direct competitors that cannot be ignored. These states also tend to be close to Kansas in many important national rankings. For example, Oklahoma is five places ahead of Kansas when ranked nationally by population (#29 vs. #34), but only one place ahead when ranked nationally by Gross State Product, or the size of its economy (#30 vs. #31).

Competition between states, whether it is over capturing limited federal resources, attracting critical investment by industry, or attracting the most brilliant and promising researchers, is intense, and it is only growing stronger. Nonetheless, it would be a mistake to view other states solely from a competitive perspective. In today’s inter-connected economy, the states, which are Kansas’ fiercest competitors, may also be the same states with which Kansas has the closest cooperation and collaboration. This is especially true of Kansas’ four neighbors.

Figure 3 – Inter-connected Hubs and Nodes



Evidence gathered during more than thirty projects in various locations in the U.S and abroad, as well as from the tracking of forty five regions nationally and globally, has led NES to conclude that the traditional self-contained cluster model is evolving into more specialized networks. This mirrors the fundamental change in the business model for the very industries comprising the clusters in most states. Over the past twenty years, the regional economic development model based on Dr. Michael Porter’s initial work on clusters at Harvard University has been transformed by the influence of a number of factors, including outsourcing, decentralization, and non-localized vendor-supplier chains. To analyze and benchmark the future challenges and opportunities for Kansas, recognition of this transformation requires new thinking and the designing of appropriate responses.

NES has sought to examine the current asset-base of the Kansas cluster within the borders of the state, and then sought to examine that asset-base relative to networking with other U.S. and foreign locations. Those regions in the world that are committing resources and plans towards connecting their assets and infrastructure for biosciences are the regions that are becoming the leaders in the relentlessly competitive bioscience economy.

5 – Assessment Methodology and Approach

Overview of Work Plan:

New Economy Strategies' work plan included hard data collection and analysis, anecdotal commentary and stakeholder perspective, regional engagement of vital partners and end-users, and ultimately an overarching exposure and awareness of the biosciences as an economic engine for Kansas' competitiveness. The goal of this multi-faceted approach was to reach consensus for a statewide Road Map and implementation plan that built on the current bioscience efforts and highlighted emerging target areas for future investment.

The Hot Team Process:

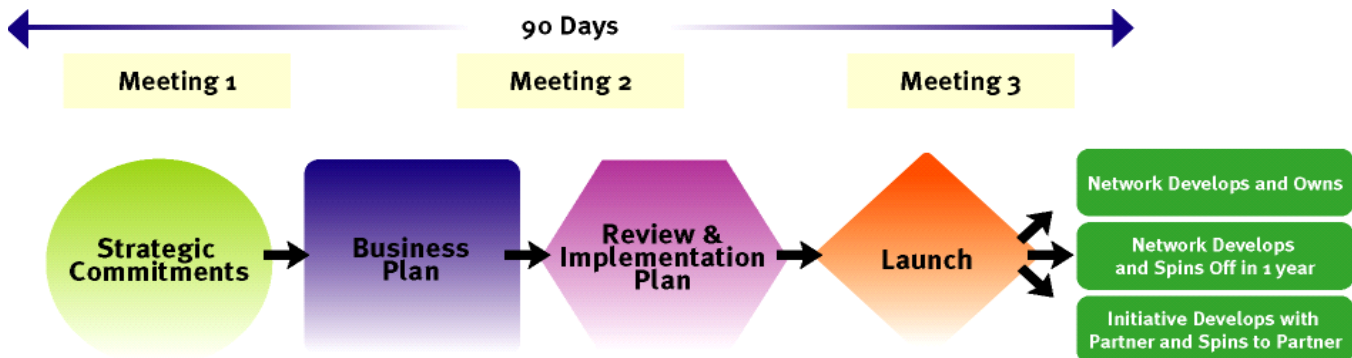
The Hot Teams played an integral part in creating the Road Map. The Hot Teams were comprised of 12-18 individuals representing key academic and non-profit institutions, industry players, entrepreneurs, and other key stakeholders. The Hot Teams evaluated Kansas' existing assets and competencies in the Target of Opportunity areas, and determined the state's ability to exploit these opportunities to compete in the global marketplace.

The Hot Teams chose the best of the more than forty ideas that came out of the process for further development and wrote detailed business plans outlining their expected impacts as well as strategies for their implementation. The Hot Teams used their entrepreneurial knowledge and subject matter expertise to design business plans which:

- Inventoried assets and their inter-relationships,
- Raised the visibility and credibility of existing initiatives and efforts that require greater attention for success, and
- Encouraged partnering with often-competing institutions and individuals that see highest common purpose through collaboration.

Figure 4 below details the precise flow of the work for each Hot Team, the desired results of each work session, and the expectations for action and implementation.

Figure 4 - Hot Team Process ^{xi}



Strategic Commitments:

- Define what Kansas must do to be viewed globally as an innovative location
- Identify and engage all of the existing organizations, institutions, and individuals working towards a similar strategic commitment
- Create statements of action including specific commitments to work towards completion

Business Plan:

- Develop a succinct two page business plan identifying requirements, determining expectations for resources, and naming champions to lead implementation
- Identify the resources (time, money and reputation) necessary for success
- Articulate what the impact and outcomes will be for the region's future

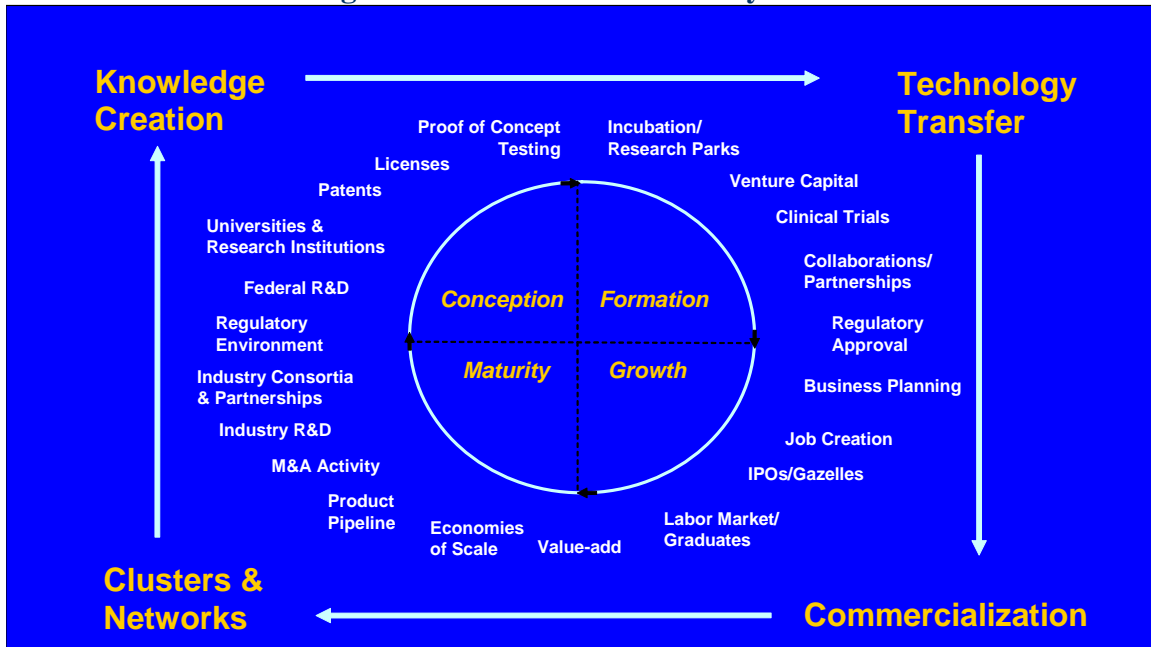
Review and Implementation Plan:

- Design an implementation plan that is actionable, sustainable, and measurable
- Identify five to ten vital performance metrics that will hold the region's "feet to the fire" regarding the implementation of the plan

The Innovation Lifecycle®:

The Innovation Lifecycle® is a four stage repeating cycle describing the life of a product or service, beginning with idea conception, moving to formation, then to growth and finally to maturity. The “cycle” in Lifecycle refers to the new company generation and spinout that occurs from mature firms, thereby completing the cycle and beginning anew. The Hot Teams evaluated both the targets of opportunity and their business plans within the context of the Innovation Lifecycle®, explaining how their ideas would impact on each of the four stages.

Figure 5 – The Innovation Lifecycle®^{xii}



The Four Stages of the Innovation Lifecycle®:

- 1) The **knowledge creation/conception** stage is the development phase. This involves idea generation, research and development, and patents. Crucial in advancing to the next stage of the Lifecycle® are internal, federal, "angel," and/or entrepreneurial capital.
- 2) The **technology transfer/formation** stage is typified by clinical trials, regulatory filings, and business planning, a phase in which the product/process proves its worth. Entrepreneurial services and support structures, investment capital, and partnering are needed to progress to the next stage.
- 3) Following clinical trials and regulatory approvals, the product/process enters the **commercialization/growth** stage. At this time, a company usually hires additional personnel, files an IPO, and begins early stage manufacturing production.
- 4) At the **cluster and network/maturity** stage, the company begins to perform in a more traditional fashion: analyzing internal business processes for improved efficiency, developing long-term marketing objectives, and, most important, delivering the product or process to the public.

6 – Qualitative and Quantitative Data

6.1 – Qualitative Data - Survey

NES developed a tool to gauge perceptions and values placed on the entrepreneurial and innovation cycle within the state of Kansas. From a suggested field of more than 1,000 respondents, we sought to measure and identify ways to close the gaps in what limits the region’s capacity to advance ideas from the bench to the market. The survey also provides a set of key actions and recommendations from which a new regional model of collaboration could be found that would link and leverage programs at academic research institutions, the private and public sector, and entrepreneurial interests.

Survey Results and Highlights

Kansans are moderately upbeat about the innovation environment. About half (48%) of the respondents felt that their regional innovation environment was either “good” or “excellent,” and three quarters (74%) felt that it would improve over the next two years. Another key indication of the respondents’ satisfaction with their region’s overall innovation and business environment is the likelihood that, should they start a business, they would choose to do so in the region in which they live. 62% were “likely” or “very likely” to do so, whereas 8% were “not likely” or “not likely at all.”

Table 10 - Survey Respondents’ Satisfaction with Business Climate Factors in Kansas

Business Climate Factor	Satisfied/Very Satisfied	Neither	Dissatisfied/Very Dissatisfied
Quality of Life	90%	6%	4%

Access to Venture Capital	13%	36%	51%
Regulations on Business	49%	36%	15%
Cost of Doing Business	43%	29%	28%
Quality of Research Universities	63%	20%	17%
Quality of K-12 Math & Science	54%	22%	25%
Collaboration between Businesses, Universities, Government	41%	30%	29%
Interaction between Innovators, Entrepreneurs, Venture Capitalists	22%	38%	40%
Overall Entrepreneurial Mindset	50%	26%	25%
Talent Recruitment Services	26%	39%	35%
<i>Because of rounding, totals may not equal 100%</i>			

As Table 10 above shows, by far the most significant positive finding of the survey was that 90% of respondents approved of the quality of life in Kansas. The most resounding negative finding, on the other hand, was that only 13% approved of the access to venture capital in Kansas.

Other relative positives included the regulatory environment (49% “satisfied” or “very satisfied,” vs. 15% “dissatisfied” or “very dissatisfied”), the cost of doing business (43% “satisfied” or “very satisfied,” vs. 28% “dissatisfied” or “very dissatisfied”), the quality of research universities (63% “satisfied” or “very satisfied,” vs. 17% “dissatisfied” or “very dissatisfied”), and the overall entrepreneurial mindset (50% “satisfied” or “very satisfied,” vs. 25% “dissatisfied” or “very dissatisfied”).

Other relative negatives included “Interaction amongst innovators, entrepreneurs, and venture capitalists” (22% “satisfied” or “very satisfied,” vs. 40% “dissatisfied” or “very dissatisfied”), and talent recruitment (26% “satisfied” or “very satisfied,” vs. 35% “dissatisfied” or “very dissatisfied”). The fact that only 26% of respondents were “satisfied” or “very satisfied” with Kansas’ talent recruitment services implies that, despite its high quality of life, Kansas has difficulties attracting the high quality workers that it needs.

When respondents were asked about personal involvement in innovation and technology acquisition, however, none of the options offered in the survey were selected by more than a third of the respondents. Almost half (49%) of respondents indicated that their organizations were “not involved in innovation or research.” This would indicate that there are untapped opportunities for Kansas organizations to establish more research collaboration with academia, research institutions and private industry. Additionally, there is very little (responses never exceeded 8%) licensing of proprietary technology is taking place with private companies, research laboratories, independent entrepreneurs, universities or federal laboratories.

These results underscore the fact that increasing Kansas’ bioscience competitiveness is not merely a question of changing the regulatory or tax environment – rather, it is a question of increasing collaboration, cooperation, and leadership across and between all involved institutions,

entities, and regions. Certainly, the results show that there is room for improvement concerning many of Kansas' fundamentals. But the most telling results point to collaborative answers – increasing the Kansas' branding and marketing efforts in order to attract new businesses, workers, and researchers, for example.

Impact: The results of the survey generally confirmed and reinforced other findings. Survey participants agree that Kansas is both a good place to live and a good place to do business. However, they also agreed that the state is failing in important areas, such as attracting the funding and talent that are critical to the development of a successful bioscience economy.

6.2 – Qualitative Data - Regional Summits

NES determined, at the outset, that individuals and institutions within and beyond the region could provide valuable insight, knowledge, and anecdotes about Kansas' competitiveness and innovation process in biosciences. Six summits were held throughout the state to share preliminary findings, generate feedback on initial recommendations and gauge perceptions and mindsets of stakeholders and leaders.

Table 11 - Locations and Dates of Regional Bioscience and Innovation Summits

Summit	Location	Date
East Central Regional Summit	University of Kansas, Overland Park	10/4/2004
Northeast/East Central Regional Summit	University of Kansas, Lawrence	10/4/2004
North Central Regional Summit	Kansas State University, Manhattan	10/5/2004
Southwest/Northwest Regional Summit	Fort Hays State University, Hays	10/6/2004
South Central Regional Summit	Wichita State University, Wichita	10/7/2004
Southeast Regional Summit	Pittsburg State University, Pittsburg	10/7/2004

Regional Summit Outcomes:

Participants in the regional summits identified a number of challenges facing the Kansas bioscience industry, including the preventing human capital flight (“brain drain”), identifying the proper role that high schools can play, reversing a decline in K-12 math and science education, increasing the exposure of high school students to new technology careers, creating links between community colleges and four year institutions, finding ways to leverage Kansas' military assets, and successfully promoting Kansas outside of the state. As well, summit participants identified a gap in both the structure and the leadership involving the commercialization of intellectual property and other business opportunities within the state.

New ideas that sprang from the summits included attracting global testing, clinical trials, and product development; focusing on the bioscience applications of plants, seeds, and other forms of agriculture; leveraging Kansas’ century-old expertise in animal management and production; and developing the new materials, engineering, and manufacturing processes that are impacting bioscience opportunities.

Impact: Participants stressed that Kansas must find unique, distinguishing assets on which to ‘leap-frog’ the competitive environment in the biosciences. Kansas needs to assess its current strengths for future relevancy - strengthening the assets, programs, and initiatives that Kansas already has in place will help it become a national and global leader. Participants highlighted Kansas’ failure to link, leverage and collaborate to compete globally. Each region in Kansas can contribute to the state’s success (be it through technical or scientific expertise, industry experience, or skills and competencies), but they must work together more closely. Kansas must increase the connectivity and communication across fields of research, commercialization, market development, and branding.

6.3 – Quantitative Data - Federal R&D Funding

Table 12 - Research and Development Statistics, Kansas and Competitor States, 2002 ^{xiii}

States	Total R&D Performance, 2002 (millions of \$)	National Rank	Federal R&D Obligations, 2002 (millions of \$)	National Rank	Total Federal R&D Funding to Universities & Colleges, FY 2002*	National Rank	
Leaders	CA	51,388	1	15,686	1	2,726	1
	NY	13,354	5	3,747	5	1,670	2
	PA	9,763	9	3,162	7	1,327	3
	MD	9,030	10	7,192	2	1,303	4
	TX	14,223	4	3,374	6	1,256	5
	MA	14,316	3	4,659	4	1,196	6
Neighbors	MO	2,478	26	1,203	22	519	12
	CO	4,218	19	1,609	19	434	17
	KS	1,865	28	291	38	119	36
	OK	793	38	272	40	119	37
	NE	663	40	145	44	99	39
US Total	255,707	N/A	83,764	N/A	\$21,352	N/A	

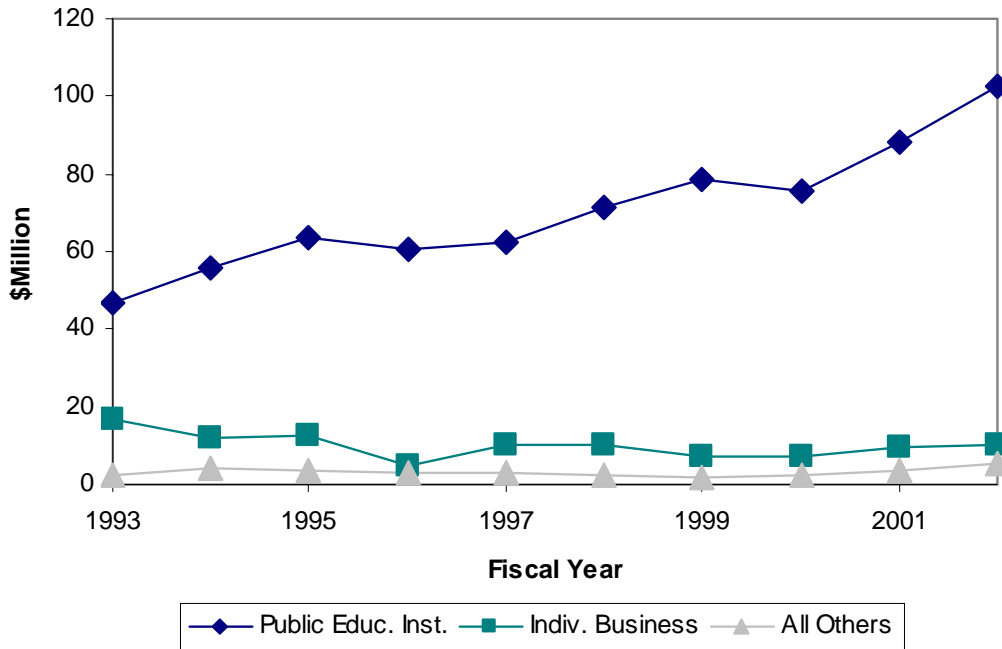
*Obligations in millions of \$. Includes medical schools

Table 13 - Industry R&D in Kansas and Competitor States, 2002 ^{xiv}

States		Industry R&D, 2002 (millions of dollars)	National Rank	<i>Per Capita</i> Industry R&D
Leaders	CA	39,664	1	\$1,118
	NY	9,234	6	\$481
	PA	7,064	9	\$571
	MD	3,800	13	\$690
	TX	10,744	4	\$486
	MA	10,279	5	\$1,598
Neighbors	MO	1,592	23	\$279
	CO	2,823	19	\$620
	KS	1,427	24	\$524
	OK	412	35	\$117
	NE	342	36	\$197
US Total		182,403	N/A	\$619

Federal R&D obligations to Kansas in 2002 were \$291 million or \$107 per capita, placing it in 38th place nationally. At only 38% of the national per capita average of \$284, this represents a significant gap. Kansas was ranked 28th in the nation by total R&D performance in 2002, with \$1.8 billion. One of the reasons why Kansas ranked comparably higher in total R&D performance than it did in some of the Federal R&D categories is that R&D by industry in Kansas is relatively robust, totaling \$1.4 billion in 2002. This placed Kansas in 24th place nationally. Per capita industry investment in R&D in Kansas was \$524, only 15% below the national per capita average of \$619, and within range of all of the competitor states except for Massachusetts and California.

Figure 6 - 1993 – 2002 Federal Funding to Kansas, by Performer Type

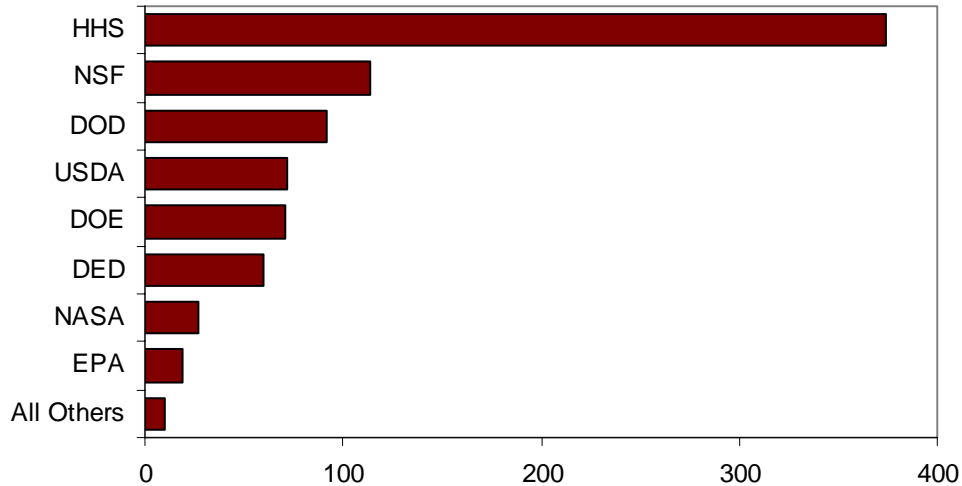


In the ten-year period from 1993 to 2002, Kansas received a total of \$837.7 million in federal funding. As Figure 6 shows, public education institutions captured the vast majority of this funding. What’s more, the amount of federal funding that they received increased steadily over the ten-year period, in contrast to the slight decline in funding captured by individual businesses.

Over half of this funding, \$437.4 million, went to the life science and biotechnology sector. Federal funding directed at other technology sectors which are important to Kansas’ bioscience economy included \$72.2 million to the agricultural technology sector, \$70.4 million to the energy sector, \$32.1 million to the environmental technology sector, \$15.7 million to the advanced materials sector, \$9.6 million to the advanced computing sector, and \$3.0 million to the telecommunications sector.

As Figure 7 shows below, the vast majority of federal funding to Kansas comes from the Department of Health and Human Services, with the National Science Foundation and the Departments of Defense, Agriculture, Energy, and Education playing important roles.

Figure 7 - 1993 – 2002 Unrestricted Federal Funding to Kansas by Agency(millions of \$)



Impact: Although industry R&D in Kansas is at respectable levels, when it comes to **federal** R&D obligations, Kansas was ranked only #38 nationally in 2002. One of Kansas' top goals over the next three to five years should be to advance from being one of 22 EPSCOR states (states which have historically attracted low levels of federal R&D funding) to become one of the top 25 states for federally-funded science, technology and innovation.

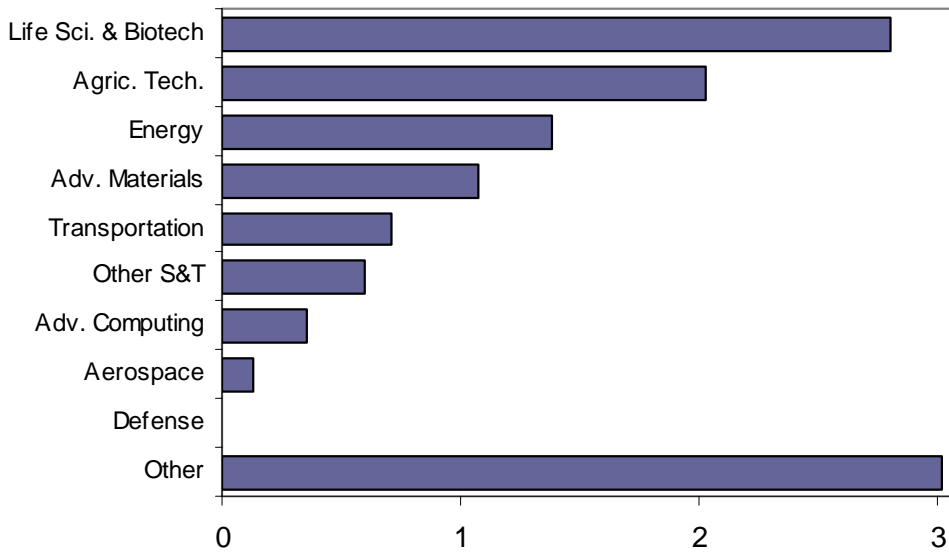
Federal SBIR/STTR Funding:

Description of the SBIR/STTR Programs ^{xv}

"The Small Business Innovation Research Program (SBIR) is a highly competitive program that encourages small business to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

The Small Business Technology Transfer Program (STTR) is an important new small business program that expands funding opportunities in the federal innovation research and development arena. Central to the program is an expansion of the public/private sector partnership to include joint venture opportunities for small businesses and the nation's premier nonprofit research institutions. STTR's most important role is to foster the innovation necessary to meet the nation's scientific and technological challenges in the 21st century."

Figure 8 - 1993 – 2002 Unrestricted SBIR/STTR Funding to Kansas by Technology Sector (millions of \$)



In the ten-year period from 1993 to 2002, Kansas small businesses received a total of \$12.1 million in federal funding under the SBIR and STTR programs. Small businesses in the life science and biotechnology sector received the most funding, followed by small businesses in the agricultural technology, energy, and advanced materials sectors (Figure 8). In the four-year period from 1999 to 2002, small businesses in Kansas received 71 SBIR awards, or 2.61 awards per 100,000 population, putting Kansas in 34th place nationally (Table 14). This represented only 39.6% of the US *per capita* average of 6.58 awards per 100,000 population over the same time period. It is worth noting that Colorado ranked 4th nationally over the same time period, with 984 SBIR awards.

Table 14 - Number of SBIR awards, 1999-2002 ^{xvi}

States		SBIR Awards	National Rank
Leaders	CA	3,923	1
	NY	751	6
	PA	663	9
	MD	958	5
	TX	740	7
	MA	2,792	2
Neighbors	MO	88	29
	CO	984	4
	KS	71	34
	OK	63	36
	NE	35	47
US Total		19,383	N/A

Federal R&D Funding to Kansas Institutions of Higher Education:

Table 15 - Overview of Federal Funding at Kansas Universities and Colleges ^{xvii}

Universities and Colleges	Federal R&D Funds Received in FY 2002 (Obligations+)	Degrees Granted					Number of Students		
		BA/BS	MA/MS	PhD	DVM	MD	Undergraduate Students	Graduate and First Professional Degree Students	Total
Baker University	0	X	X				1,903	1,016	2,919
Barclay College	0	X					196	0	196
Benedictine College	0	X	X				1,288	0	1,288
Bethany College	0	X					604	0	604
Bethel College	0	X					525	0	525
Central Christian College	0	X					314	0	314
Emporia State University	52,106	X	X	X			4,287	0	4,287
Fort Hays State University	84,021	X	X				4,565	1,061	5,626
Friends University	0	X	X				2,629	561	3,190
Haskell Indian Nations University	162,000	X					967	0	967
Kansas State University	29,309,846	X	X	X	X		18,770	3,626	22,396
Kansas Wesleyan University	0	X	X				722	62	784
Manhattan Christian College	0	X					412	0	412
McPherson College	0	X					397	0	397
Mid-America Nazarene College	0	X	X				1,290	393	1,683
Newman University	0	X	X				1,660	411	2,071
Ottawa University	0	X	X				953	756	1,709
Pittsburg State University	663,915	X	X				5,471	1,252	6,723
Saint Mary College	0	X	X				484	288	772
Southwestern College	0	X	X				1,177	99	1,276
Sterling College	0	X					461	0	461
Tabor College	0	X	X				571	21	592
University of Kansas (all branches)	45,758,948	X	X	X			19,651	6,131	25,782
University of Kansas Medical Center	41,273,167	X	X	X		X	409	1,999	2,408
<i>School of Medicine*</i>	<i>36,588,814</i>								
Washburn University	0	X	X				5,098	1,020	6,118
Wichita State University	2,149,610	X	X	X			11,303	3,551	14,854
TOTAL	119,453,613						86,107	22,247	108,354

+ Obligations are binding agreements that will result in outlays immediately or in the future. Budgetary resources must be available before obligations can be incurred legally, according to the United States Budget.

* The University of Kansas Medical Center consists of the Schools of Allied Health, Medicine, Nursing and Graduate Studies, all of which are eligible to receive federal R&D funds. Note that these funds are included in the total provided for the University of Kansas Medical Center on the line above.

Federal obligations for R&D to Kansas colleges and universities totaled \$119.5 million in fiscal year 2002. More than one third of that money, \$41.3 million, went to the University of Kansas Medical Center, home to Kansas' lone medical school. Outside of the University of Kansas system, the only other recipients of federal R&D funding were Emporia State U., Fort Hays State U., Haskell Indian Nations U., Kansas State U., Pittsburg State U., and Wichita State U.

6.4 – Quantitative Data – Patents

Another integral part of the data collection and analysis portion of this process was a comprehensive analysis of Kansas’ patenting activity, including the number of patents and related citations, scientific and technology strength, and innovation speed. This analysis was conducted by 1790 Analytics, LLC, Inc. of Mount Laurel, New Jersey.

Note that patent activity is often correlated with R&D spending but is not correlated with any other measure of success. As a rule, big companies have a lot of patents and small companies have fewer. Success depends, however, on having a few high impact patents rather than having a lot of mediocre patents. A driving force in technology-based economic development is the ability to convert such intellectual property into new products and services. This, in turn, has positive residual effects for attracting venture and corporate investment.

Patent Activity:

Figure 9 compares patents invented in Kansas and the United States since 1990. The graph indicates that Kansas had mirrored the nation as a whole in the early nineties, but has been trending faster than the rest of the country in recent years. Note that Kansas (and the US as a whole) has doubled its patenting since 1990.

Figure 9 - Growth in Patenting, US and Kansas, 1990 - 2002

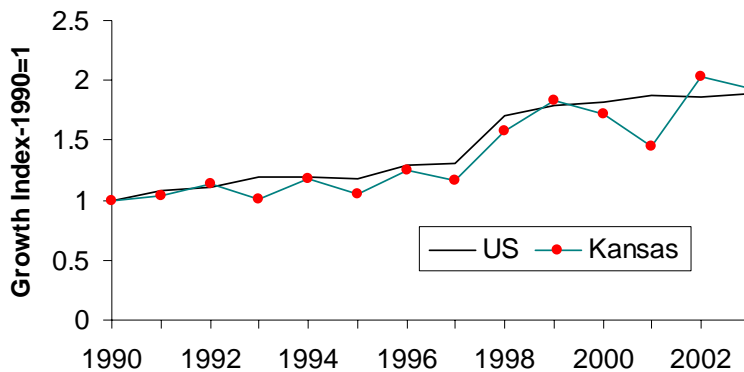


Figure 10 – Patent Totals and Growth by Region

Region	# of Patents		% of Total		% Growth from first seven year period (1990 - 1996) to second seven year period (1997 - 2003)
	1990 - 1996	1997 - 2003	1990 - 1996	1997 - 2003	
EastCentral (KC Metro)	939	1626	45.3%	51.7%	73%
SouthCentral (Wichita)	578	806	27.9%	25.6%	39%
NorthCentral (Manhattan)	246	270	11.9%	8.6%	10%
NorthEast (Lawrence)	107	205	5.2%	6.5%	92%
Southwest (Garden City)	97	127	4.7%	4.0%	31%
SouthEast (Pittsburg)	98	111	4.7%	3.5%	13%
Northwest (Hays)	53	58	2.6%	1.8%	9%
All Kansas	2074	3145	100.0%	100.0%	52%

Figure 11 - Statewide Patent Totals and Growth by Technology Category

Category	Total Patents, 1990 - 2003	Percentage of 1990 - 2003 Patent Total	% Growth from first seven year period (1990 - 1996) to second seven year period (1997 - 2003)
Agriculture	436	8.2	45
Food and Foodstuffs	115	2.2	74
Meat & Poultry Butchering and Processing	32	0.6	13
Cleaning Compositions	9	0.2	700
Fire Extinguishing/Prevention/Resisting	12	0.2	200
Inorganic Chemistry	27	0.5	45
Misc. Chemistry	71	1.3	22
Organic Chemistry	137	2.6	143
Plastics, Polymers & Rubber	123	2.3	28
Batteries	12	0.2	40
Computers and Peripherals	283	5.3	264
Navigation/Radar/Avionics	80	1.5	371
Semiconductors and Electronics	41	0.8	-5
Telecommunications	326	6.1	198
Biotechnology	64	1.2	6
Medical Electronics	72	1.4	224
Medical Equipment	328	6.2	33
Pharmaceuticals	234	4.4	49
Building/Home Construction	174	3.3	32
Filters & Membranes	30	0.6	300
Home Furnishings and Appliances	205	3.9	85
Road, Railway, and Heavy Construction	99	1.9	83
Ventilation/Ducts/Fans	32	0.6	91
Furnaces/Kilns/Heat Exchange	49	0.9	-4
Machining/Metal Working	116	2.2	32
Misc. Machinery & Tools	247	4.7	1
Misc. Manufacturing	114	2.1	78
Containers and Packaging	138	2.6	16
Paper Production and Handling	59	1.1	-41
Freight Handling (Conveyors, Rail, etc.)	80	1.5	0
Oil & Gas, Mining	75	1.4	68
Oxygen Systems (especially for aircraft)	17	0.3	367
Sports and Recreation	105	2.0	14
Aerospace	36	0.7	127
Motor Vehicles and Parts	147	2.8	33
Other Transport	72	1.4	40
Vehicle Brake Systems	7	0.1	150
Everything Else	1103	20.8	23
All	5307	100.0	-34

Currently the state's largest patenting categories include Agriculture, Telecommunications, Computers and Peripherals, Medical Equipment, Pharmaceuticals, and Agriculture (Figure 11).

The categories of Telecommunications and Computers and Peripherals have increased dramatically.

Key Findings:

- Nearly 8% of all patents from Kansas inventors in the last seven years are in the telecommunications category. The area is dominated by Sprint, which has 124 of the state's 244 telecom patents in the last seven years. The citation impact that suggests its patents are cited 41% more than expected. This gives Kansas a high impact technology that it did not have 8 years ago.
- Agriculture is the biggest category for Kansas with 258 patents (8% of total) and a growth of 45% in the last seven years. The citation impact and innovation speed of patents in this area are slightly below average and the science linkage metric is well below average. This suggests that the state produces a lot of patents in the category but their quality is weaker than the national averages for the same category.
- The Computers and Peripherals category is noteworthy because it is large (222 patents in the last seven years) growing fast (264% growth rate) and has an above average citation rate (1.11). Most of the patents in this category are owned by LSI Logic and invented in the Wichita area.
- Taken as a group the categories of Biotechnology, Medical Electronics, Medical Equipment, and Pharmaceuticals make up nearly 13% of all patents invented in Kansas. However, as in Agriculture the patents are fairly weak in terms of citation impact compared to the rest of the country's patents in these areas.
- The Kansas City Metro area accounts for nearly 52% of all patents invented in Kansas in the last seven years. This region's patenting is also growing at a fairly high rate (second only to the Lawrence region).
- The greater Wichita region is the second largest patenting region making up roughly 26% of the patent output for the state.
- More than three quarters of all patents invented in the state came from the greater Kansas City and Wichita regions.
- There are significant differences between the regions regarding categories. For example, in the greater Kansas City region the top patenting categories are Telecommunications, Medical Equipments and Pharmaceuticals, whereas in the Lawrence area the top categories are Food, Machinery and Agriculture.
- The top patenting organizations vary significantly by region as well. The top patenters in the Kansas City region are Bayer, Sprint, and Garmin, while the top patenters in the Manhattan area are Kansas State University, Hopkins Mfg., and Deere and Company.

Impact: In the knowledge economy, the key to success lies in obtaining, creating, developing, and commercializing intellectual property. Although there are significant variations across both regions and technology categories, at a statewide level Kansas has a solid base of intellectual property. Kansas has performed strongly in recent years in many patent categories, both in terms of total numbers and in terms of growth rates. However, Kansas has yet to leverage its patrimony of intellectual property into significant new company creation.

6.5 – Quantitative Data – Venture Capital Investment

Lack of venture capital funding was by far the most oft-cited criticism of the innovation and entrepreneurial environment in Kansas – only 13% of respondents were either satisfied or very satisfied with the availability of venture capital funding, compared with 51% who were dissatisfied or very dissatisfied.

The respondents' dissatisfaction is also backed up by the numbers. As Table 16 shows, venture capital investment in high technology industries in Kansas has been weak over the last decade. For every industry shown, *per capita* venture capital investment in Kansas was significantly below the national average. The gap in *per capita* venture capital was the widest in biotechnology, where the Kansas average of \$4.41 was less than one sixteenth of the national average of \$73.15. The gap in Medical Devices and Equipment was not much better – at \$3.27 *per capita*, Kansas invested less than one thirteenth the national average of \$44.68.

Table 16 - Venture Capital Activity by Industry, Kansas and the US, 1995 - 2003 ^{xviii} (millions of \$)

Year	Biotechnology		Financial Services		IT Services		Medical Devices		Software		Telecom	
	KS	US	KS	US	KS	US	KS	US	KS	US	KS	US
1995		861.4		189.4		187.1	4.0	703.2		1,125.4		1,013.2
1996		1,209.6	5.5	377.6		462.2	3.4	676.1	2.8	2,265.6		1,264.4
1997		1,482.8	4.0	425.7		627.9		1,004.7	0.1	3,282.6		1,636.4
1998		1,565.1	8.0	949.4		1,125.5		1,194.2	10.4	4,290.8		2,998.8
1999		2,193.9		2,289.7		4,291.3		1,468.5		9,713.2		8,274.3
2000	12.0	4,300.6		4,189.3	13.3	9,100.3	1.5	2,580.4	19.1	21,433.1	117.7	17,943.9
2001		3,343.6		1,477.1	3.0	2,726.1		2,048.5	3.8	9,353.8	14.9	6,176.6
2002		3,032.1		468.5		1,177.5		1,877.1	0.5	4,696.7		2,555.0
2003		3,566.5		425.5		777.1		1,614.0		3,875.7	2.9	1,931.3
Total VC, 1995-2003												
	12.0	21,555.7	17.5	10,792.1	16.3	20,474.8	8.9	13,166.8	36.6	60,036.9	135.5	43,793.8
VC per capita, 1995-2003*												
	\$4.41	\$73.15	\$6.42	\$36.62	\$5.98	\$69.48	\$3.27	\$44.68	\$13.43	\$203.73	\$49.75	\$148.61

*Total 1995-2003 dollar amount divided by 2003 population, according to US Census Bureau (KS = 2,724,000, US = 294,688,000). Blank cells indicate years in which Kansas had no venture capital activity

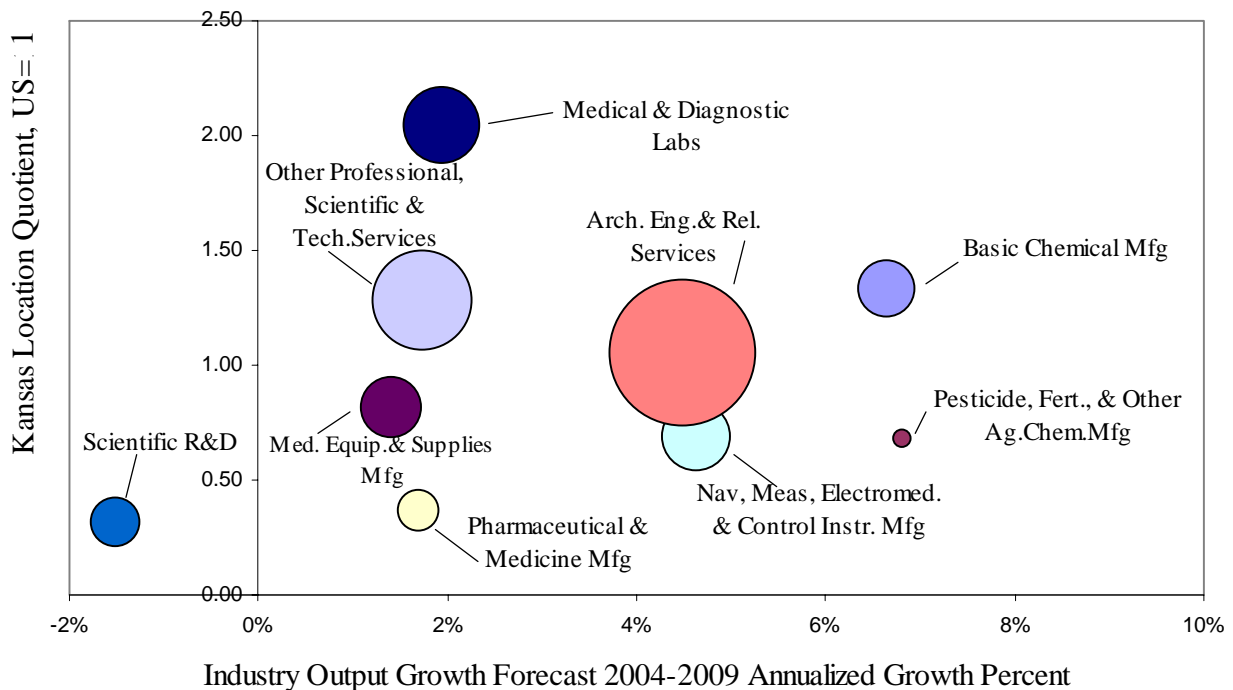
Impact: Because adequate venture capital funding is not readily available, it is more difficult to fund start-up businesses in Kansas. This is especially true for bioscience companies, which require a greater investment of time and capital to bring a product to market than do start-up companies in most other sectors. If Kansas cannot increase the amount of available venture capital funding, it will not be able to achieve the desired rate of new company generation, and it will be difficult to achieve the critical mass of bioscience companies, which is necessary to the formation of a bioscience cluster.

6.6 – Quantitative Data – Workforce Composition

The competitiveness of the Kansas labor market (see Figure 10) has a rather wide degree of variation across the occupation categories that we associate as drivers of innovation and technology growth. Within the fields of health care, education, and engineering occupations Kansas has a relative high concentration of workers. This constitutes a competitive advantage for firms and industries that rely heavily on these vital occupations.

The higher education and job training related occupations have slightly higher than normal concentration in Kansas. Collectively it is the largest employment category in the state with nearly 83,000 workers employed (see Table 17 on the next page). The state has above normal concentrations in the fields within the biological sciences, earth sciences, chemistry, and health specialties. However, among education departments that teach computer and mathematics sciences the state has considerably less than its share relative to national averages.

**Figure 12 – Kansas Bioscience Occupational Analysis
(NAICS Codes from Kansas Growth Act Legislation Shown)**



Overall, engineers are employed at relatively high levels in Kansas, although the growth in engineering as a broad category is not keeping pace with the nation. There are roughly 26,000 engineers employed in Kansas; the fastest growing fields are within the civil, electrical, and advanced materials areas (Table 17). In each of these occupations Kansas has an above average concentration of workers and the fields are growing faster than the national average. In the fields of agricultural, biomedical, chemical, and environmental engineering, Kansas has an average representation given the size of the state economy but each of these fields are growing at rates slower than the national growth rate.

Impact: Figure 10 shows both positives and negatives. There is a generally high concentration (compared to the national average of 1.0) and moderate to strong growth in many bioscience occupations in Kansas, but gaps include the pharmaceutical manufacturing industry (insignificant size, growth, and concentration) and scientific R&D occupations (their negative growth rates are a cause for concern).

Table 17 – Kansas Employment and Wages in Key Occupations^{xix}

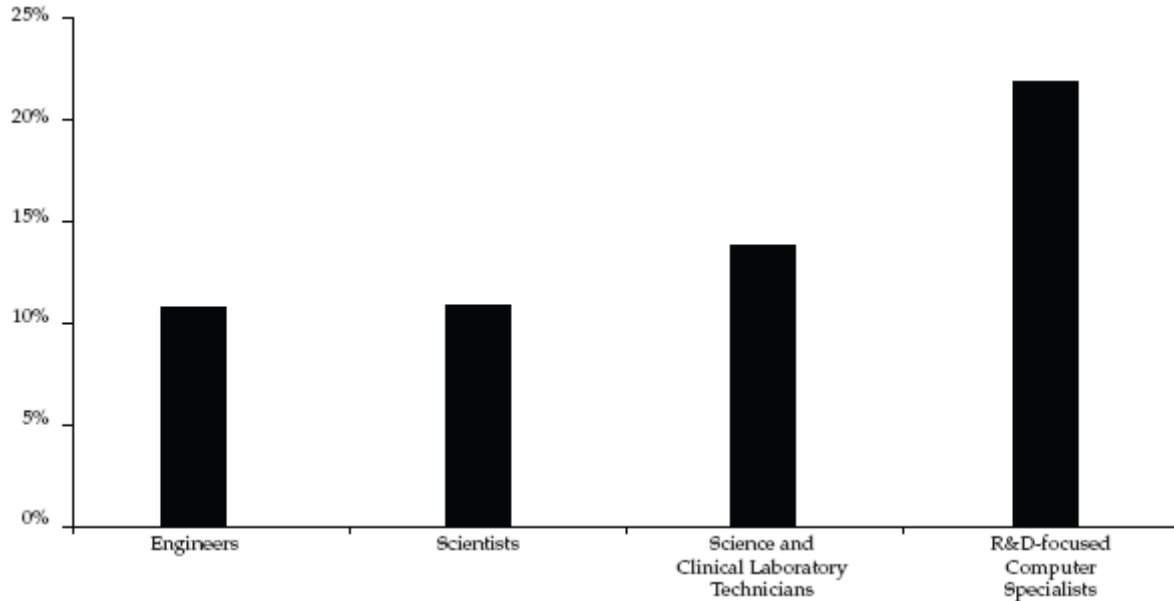
Occupations	Employment				Wages					
	2000	2003	Percent Change, 2000 - 2003		2000 Average Annual Wage		2003 Average Annual Wage		Percent Change, 2000 - 2003	
			Kansas	US	Kansas	US	Kansas	US	Kansas	US
Management	84,250	61,560	-26.9%	-14.5%	\$53,760	\$61,310	\$62,970	\$70,870	17.1%	15.6%
Business and Financial Operations	42,490	46,950	10.5%	6.6%	\$41,450	\$43,900	\$45,930	\$49,260	10.8%	12.2%
Legal	6,960	7,230	3.9%	6.8%	\$43,050	\$56,880	\$45,220	\$59,200	5.0%	4.1%
Computer and Mathematical	26,770	27,080	1.2%	-3.6%	\$50,340	\$55,110	\$57,050	\$60,060	13.3%	9.0%
Architecture and Engineering	26,730	26,240	-1.8%	-7.7%	\$48,140	\$51,530	\$53,820	\$55,930	11.8%	8.5%
Life, Physical, and Social Science	8,080	9,610	18.9%	7.2%	\$41,270	\$43,090	\$45,350	\$46,970	9.9%	9.0%
Education, Training, and Library	81,430	82,840	1.7%	5.1%	\$29,740	\$34,900	\$31,320	\$37,430	5.3%	7.2%
Healthcare Practitioners and Technical	60,100	63,950	6.4%	2.2%	\$34,940	\$41,080	\$39,360	\$44,990	12.7%	9.5%
Healthcare Support	35,640	38,530	8.1%	5.6%	\$18,090	\$19,760	\$20,000	\$21,360	10.6%	8.1%
Farming, Fishing, and Forestry	1,890	2,480	31.2%	0.2%	\$19,010	\$15,260	\$21,090	\$16,910	10.9%	10.8%

Health care and supporting occupations account for roughly 100,000 workers in Kansas (Table 17). Within health care the strongest fields are in the primary care support fields like registered nurses, physical therapists, medical technicians, respiratory therapists, and health specialists. In the disciplines and occupations that require higher levels of education and training including general practitioners, surgeons, anesthesiologists, optometrists, and pharmacists Kansas has fewer workers than expected given the states size. However, most of the fields in the higher end health care category are currently growing faster than the national average and at current growth rates will reach the national average within three to five years. The combined life, physical, and social science category grew by an impressive 18.9% over the three-year period.

Although Kansans earn less than the national average in most occupations, there are signs that wages are converging. For example, wages grew at a faster rate in Kansas than they did nationally in all but two of the occupations listed in Table 17.

National Growth in Biotech-related Employment:

Figure 13 - Annual Growth Rate in Biotech-related Technical Occupations, 2000-2002 ^{xx}



A 2002 study by US Commerce Department (Figure 11 above) showed strong growth in recent years in biotechnology-related occupations such as engineers and scientists (about 11%), science and clinical laboratory technicians (about 14%), and R&D-focused computer specialists (about 22%). The US Department of Labor predicts strong double-digit growth rates for almost all biotechnology-related occupations over the period of 2002 – 2012 (see Table 18 below).

Table 18 - Biotech-Related Occupations and their Projected 10 Year Growth ^{xxi}

Occupation Title	Number Employed 2002 (thousands)	Number employed 2012 (thousands)	Numeric Change (thousands)	% Change	2002 Median Annual Earnings	Postsecondary Education & Training
Medical scientists, except epidemiologists	58	73	16	26.9	56,980	Doctor's degree
Biomedical engineers	8	10	2	26.1	60,410	Bachelor's degree
Environmental scientists and specialists, including health	65	80	15	23.7	47,600	Master's degree
Biological scientists, all other	27	33	6	22.3	53,300	Bachelor's degree
Biological technicians	48	57	9	19.4	29,040	Associate's degree
Chemist	84	95	11	12.7	52,890	Bachelor's degree
Agricultural & food science technicians	20	22	2	9.3	28,580	Associate's degree
Chemical technicians	69	72	3	4.7	37,430	Bachelor's degree

6.7 – Academic R&D and Science and Engineering Degree Production

Table 19 - Academic and Public Sector Expenditures on Higher Education ^{xxii}

States		Academic R&D, 2002 (millions of \$)	National Rank	% of Academic R&D Invested in Life Sciences	Amount of Academic R&D Invested in Life Sciences (millions of \$)	Public Higher Education Current-fund Expenditures, 2001 (millions of \$)	National Rank	Per capita Public Higher Education Current-fund Expenditures
Leaders	CA	\$4,882	1	58%	\$2,832	\$22,675	1	\$639
	NY	\$2,774	2	68%	\$1,886	\$13,542	2	\$706
	PA	\$1,913	4	59%	\$1,129	\$6,455	5	\$522
	MD	\$1,880	5	47%	\$884	\$3,141	18	\$570
	TX	\$2,535	3	66%	\$1,673	\$12,744	3	\$576
	MA	\$1,706	6	47%	\$802	\$2,337	27	\$363
Neighbors	MO	\$706	15	81%	\$572	\$2,837	20	\$497
	CO	\$645	19	45%	\$290	\$2,630	23	\$578
	KS	\$300	31	64%	\$192	\$1,831	32	\$672
	OK	\$282	34	47%	\$133	\$2,129	29	\$606
	NE	\$267	35	66%	\$176	\$1,259	36	\$724
US Total		\$36,314	N/A	59%	\$21,425	\$170,024	N/A	\$577

Table 20 – Science & Engineering PhDs Awarded in Kansas and Competitor States, 2002 ^{xxiii}

States		S&E PhDs Awarded, 2002	National Rank	PhDs in Life Sciences	% of S&E PhDs that are in Life Sciences
Leaders	CA	3,232	1	711	22%
	NY	2,124	2	595	28%
	PA	1,207	6	278	23%
	MD	638	11	211	33%
	TX	1,462	3	424	29%
	MA	1,461	4	336	23%
Neighbors	MO	409	20	127	31%
	CO	457	18	101	22%
	KS	275	28	85	31%
	OK	196	32	47	24%
	NE	150	36	36	43%
US Total		24,558	N/A	6,631	27%

\$300 million was spent on academic R&D in Kansas in 2002, putting it in 31st place nationally. Significantly, 64% (\$192 million) of that money was invested in R&D in the life sciences, higher than the national average of 59%. \$1.8 billion was spent on public higher education in Kansas in 2001, or \$672 *per capita* – higher than the national *per capita* average of \$577, and higher than

the *per capita* averages in all competitor states except for New York and Nebraska. Kansas produced 275 science and engineering PhDs in 2002, ranking 28th nationally. 31% of those PhDs were in the life sciences - a higher percentage than the national average (27%), as well as all competitor states but Maryland, Missouri, and Nebraska.

Table 21 - Number of Universities and Colleges Receiving Federal R&D Funding vs. Total Number of Such Institutions in State, FY 2002 ^{xxiv}

States		All Degree Granting Institutions		All BA/BS Granting Institutions		All MA/MS Granting Institutions		All PhD Granting Institutions		All MD Granting Institutions	
		Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding	Total	Receiving Funding
Leaders	CA	119	55	104	53	99	50	48	28	9	9
	NY	144	78	130	71	113	66	43	35	12	12
	PA	129	48	122	14	86	35	29	17	6	6
	MD	32	19	31	18	29	17	13	11	3	3
	TX	94	51	86	49	75	46	42	35	7	7
	MA	76	34	69	32	59	28	27	21	4	4
Neighbors	MO	49	14	45	12	33	12	10	7	4	4
	CO	22	11	22	11	16	10	10	8	1	1
	KS	26	8	26	8	18	7	5	5	1	1
	OK	24	9	24	9	17	9	5	4	1	1
	NE	22	5	22	5	16	5	4	4	2	2

There are 26 degree-granting institutions in Kansas, eight of which received federal R&D funding in 2002. Of the eighteen institutions in Kansas that grant master’s degrees, seven received federal R&D funding in 2002. All five of the institutions in Kansas that grant doctoral degrees and the one institution in Kansas that grants a medical doctor degree received federal R&D funding in 2002.

Although there are many universities receiving federal R&D funding throughout the nation, the *amount* of that funding is highly concentrated - the top 80 universities and colleges in the country received 71% of all federal funding in fiscal year 2002.¹ The University of Kansas at Lawrence was the only Kansas institution represented in the list of the top 100 universities (excluding medical schools) receiving federal R&D funding in fiscal year 2002 (in 78th place with \$46 million). The only Kansas institution to make the top 50 universities receiving federal R&D funding from the USDA in fiscal year 2002 was Kansas State University (in 28th place with \$7.8 million).

Impact: Kansas has prestigious and effective institutions of higher education, but their failure to adequately capture federal R&D funding puts Kansas at a disadvantage vis-à-vis its competitor states.

¹ “Vital Assets: Federal Investment in Research and Development at the Nation’s Universities and Colleges,” RAND RaDiUS, 2004

7 – Findings

7.1 - SWOT (Strengths/Weaknesses/Opportunities/Threats) Analysis

The quantitative and qualitative data presented in Section 6, in combination with the outcomes of the Hot Team process, facilitated an analysis of Kansas’ primary strengths, weaknesses, opportunities, and threats within the bioscience and innovation economy (Table 22 below). By summarizing and distilling the results of the data collection and the Hot Team process, the SWOT analysis presents compelling picture of Kansas’ current assets and competitive position, as well as illuminating the path that Kansas should follow to future success.

Table 22 - SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • Entrepreneurial mindset • Highly-educated and hard-working labor force • Generations of expertise in key areas such as animal and plant sciences • High quality of life • Low cost of doing business • Prestigious educational institutions • Relatively high concentration of health care, education, and engineering workers • Above normal employment concentrations in biological sciences, earth sciences, chemistry, and health specialties 	<ul style="list-style-type: none"> • Talent recruitment and retention • Commercialization of Intellectual Property • Lack of venture capital at all stages • High school students lack exposure to Science & Technology career opportunities • Below average numbers of math and computer sciences teachers • Relatively low federal R&D funding (only 38% of the national per capita average in 2002) • Lack of a coordinated workforce development pipeline • Lack of critical mass of bioscience firms • Inadequate wet lab space • Lack of a community clearing house for publicizing and coordinating bioscience initiatives • Kansas is not effectively marketed outside of the state
Opportunities	Threats
<ul style="list-style-type: none"> • Medical research, specifically oncology • Animal health and food safety • Monitoring and managing biological risk • Biologically-inspired materials, biofuels • Telemedicine, health-related IT • Nutraceuticals • Write more and obtain greater share of research grants • Leverage strong military presence to realize opportunities • Increase incentives for entrepreneurialism • Improve industry-academia partnerships • Increasing amount of federal R&D funding captured 	<ul style="list-style-type: none"> • Human Capital Flight (Brain Drain) • Increased competition, both from other US states and globally • Risk of negative perceptions of Kansas in the absence of a coordinated branding and positioning effort • Dwindling base of experienced management professionals (27% drop from 2000 – 2003) • Possible reductions in corporate investment if industry fails to find compelling reasons to have a strong presence in Kansas • Political controversy regarding science policy • Risk of non-coordinated and competing bioscience efforts throughout the state.

7.2 – Cross-cutting Business and Innovation Environment Issues

Throughout the Hot Team process, and supported by initial tactics suggested during the regional forums, a number of cross-cutting business and innovation environment issues were identified. The term “Cross-cutting” was used because the challenges could be found in each of the targets of opportunity. Cross-cutting issues also arose out of the Hot Teams’ discussions for addressing implementation. The challenges – and the respective solutions – will have a significant impact on the innovation environment in Kansas. By addressing these cross-cutting issues, Kansas institutions and industries could increase their capacity to innovate scientific, technological and entrepreneurial interests.

While the Road Map process has led to the identification of distinguishing and unique scientific and technological opportunities for achieving competitiveness in the biosciences, the creation of an “ecosystem” at the state, regional, and local levels is critical for sustaining commercialization and societal benefit. Thus, our analysis of crosscutting challenges is intended to recognize the influence positive solutions could have on the emerging business model in Kansas’ biosciences, as well as on the larger context of catalyzing innovation across institutions, organizations, and individuals.

Four significant cross-cutting issues were identified and examined:

1. Workforce skills and competencies:

Survey and regional summit participants recognized that the most critical ingredient to success in the biosciences is the creation of occupation and career paths for Kansans to benefit economically from the growth of the industry. From high schools to community colleges to four-year institutions and post-graduate programs, participants suggested that the state use its existing apparatus within the public and higher education systems, coupled with workforce-employment agencies, to align training, courses, internships and other actions to ensure the successful implementation of the Road Map. Since approximately 150 of the more than 900 occupation codes inventoried by the U.S. Department of Labor have a direct impact on the biosciences, the challenge will be to prioritize the state’s assets in education and workforce to meet the needs of the “Big Ideas” and “Fundamental Actions.”

2. Infrastructure in support of collaboration and commercialization:

While Kansas has made important investments in incubator programs, the relevance of these programs may need to evolve to different models. While physical spaces should be created that bring teams of researchers together around interdisciplinary discussions for sparking new discoveries and developments, it is also going to be increasingly necessary for Kansas to advance the social aspects of innovation (for example, through the increased connectivity of principle investigators and industry partners, or of stage-three clinical trials and potential management talent) in order to build new enterprises from such trial methodology. Hot Team members have examined models around the country like UCSD Connect, and the best principles from those

models have been encouraged across the targets of opportunity as an enhancement for collaboration and commercialization.

3. Early stage, proof of concept and other resources to accelerate the bench-to-market pathways:

The so-called “Death Valley Curve” for discovery and development (the period before a new company starts generating revenues, when it is difficult for the company to raise money) will only worsen as traditional venture capital in the U.S. and abroad seeks earlier returns on investment. Timelines are becoming increasingly difficult, and are shrinking to less than the common eight to ten years of approvals and market-entry. In projects involving research of a more translational nature, the need for short-term cash flow is increasing. Last-stage clinical research with significant commercial potential is fast finding new solutions. For instance, investments made by universities in partnership with industry clusters or agglomerated industry organizations at the early stage (proof-of-concept period) in the wetlab are accelerating pathways off the bench to the market. More than traditional licensing, this is a hands-on approach to shortening the timeframe for sparking innovation.

4. Coordination and integration of communications, research, and opportunities leading to the increased efficiency of resources and energies:

There is a significant intent and willingness to collaborate in Kansas. For the Road Map process to be successful, these relationships between researchers, principal investigators, and technologists must be strengthened and sustained. There is little idea of how to increase the discussion and socialization at the local and regional levels, and then connect these discussions at the state level. A first step could be identifying the critical communications and awareness for events, programs, and work sessions through a statewide bioscience electronic calendar. There are many activities and programs across the state that could contribute to the growth of biosciences in Kansas, yet they can only contribute if they are made aware of and invited to the discussion. The creation of a permanent digital ‘commons’ in the biosciences appears to be an important next step.

8 – Hot Team Targets of Opportunity Profiles

Importance of Targeting

Critical to becoming competitive in the current technology-focused and agile economy is the ability of a state and its regions to leverage current strengths and opportunities to achieve excellence and become a global leader. Given the breadth and competitiveness of the technology industry, it is impossible to excel in every area. Targeting allows a state to hone in on a particular field and gather the specialized resources, talent, and assets necessary to become a premier destination for scientists, researchers, entrepreneurs, investors, and corporations interested in a specific industry.

At the outset, we set a framework for target selection:

- A mix of short-term economic payoff and long-term growth opportunities.
- Areas with a solid foundation in basic science and either realized or potential innovation (patent) activity.
- Existing federal funding flow or the strong potential to attract significant federal funds.
- Collaborative efforts underway or the potential for inter-institutional collaboration.
- The ability to build public and private support around future investment.

Note that each of the selected six targets of opportunity represents an area in which Kansas has the basic foundation necessary to build a competitive advantage in the global environment. The following sections provide a detailed explanation of each of the target areas, as well as the assets and elements Kansas can capitalize on to create a unique competitive advantage for the region. Federal funding trends, patent data, and other indicators are presented to illustrate the linkages, basis for selection, and the relative strength of the target within the region.

Table 23 - Hot Team Target of Opportunity Profiles

Hot Team	Description
Advanced Materials & Medical Devices	Advanced materials are a critical key to technological advancements in a number of industries. The medical device and diagnostics industry produces equipment designed to aid medical therapies.
Animal Sciences	Animal Science is the field of study involving the production, marketing, and utilization of domestic animals in agriculture, entertainment, and companionship.
Biomass, Biofuels, Biomaterials, & Other Environmental Applications	Biomass, biofuels, biomaterials, and other environmental applications represent a subset of the myriad of applications of advanced biological sciences research.
Drug Discovery, Delivery, and Pharmacogenomics	This includes target discovery and identification, lead discovery and identification, drug metabolism and toxicity, drug process and development, and application of genomics, proteomics, pharmacogenomics and bioinformatics in accelerating drug discovery and development.
Health-Related IT (including Bioinformatics and Telemedicine)	Bioinformatics is the convergence of computer science, information technology and biotechnology. Telemedicine is the use of telecommunication to provide diagnostic and therapeutic medical information between a patient and doctor without either of them having to travel.
Plant Sciences	Plant Science is the field of study involving the production, marketing, utilization and study of plants and plant materials.

8.1 – Advanced Materials and Medical Devices

Advanced Materials:

Advanced materials is the extension of research on the fundamental phenomena in condensed matter physics and solid state chemistry to functional materials including metal, ceramics, polymers, biomaterials, and electronic, photonic and magnetic materials.



This multidisciplinary area of research has traditionally engaged physicists, chemists, materials scientists, and engineers of all kinds. Increasingly, the field is benefiting from the participation of an even wider range of disciplines, including biochemistry, biology, earth sciences, mathematics, computer science, and medicine. In terms of application, advanced materials are a critical key to technological advancements in a number of industries such as electronics, information technology, transportation and aerospace, environmental protection, manufacturing, medicine and healthcare, and civil infrastructure.

Advanced materials research in Kansas received approximately \$15.7 million in federal R&D from 1993 to 2002.² When looking at the funding trend for advanced materials over the ten-year period, we see little change in the award amounts until 2000. In 1999, the state received \$1.47 million, which increased to \$2.05 million the following year. In 2001 and 2002, Kansas received \$2.34 million and \$2.35 million respectively.

Medical Devices:

The medical device and diagnostics industry produces equipment designed to aid medical therapies such as pacemakers, artificial joints, drug-eluting stents, and laparoscopic devices for minimally invasive surgery. Medical devices are commonly broken into the following categories:

- **Life support equipment:** equipment used to maintain a patient's bodily function such as medical ventilators, heart-lung machines, ECMO, and dialysis machines.
- **Therapeutic equipment:** devices that include infusion pumps (by far the most common), medical lasers and LASIK surgical machines.
- **Medical monitors:** devices that allow medical staff to measure a patient's medical state such as ECGs, EEGs, blood pressure, and dissolved gases in the blood.
- **Medical imaging machines:** equipment that aids a diagnosis such as ultrasound, MRI, CAT-scans, PET, and x-ray machines.
- **Medical laboratory equipment:** devices that automate or help analyze blood, urine and genes.

² RAND RaDiUS

The R&D intensive medical devices industry is also poised to make further advancements in the quality of care with innovations in micro-miniature and remote surgery techniques, DNA-based diagnostics, tissue-engineered organs, and advanced information technologies.

Table 24 – US Medical Device Industry Market Size by Specialty (as of October 24, 2003)

xxv

Industry Segment	Estimated Number of US Establishments	Number of People Employed	Average Number of Employees per Establishment	Total Annual Sales (Millions)	Average Sales per Establishment (Millions)
Surgical and Medical Instruments	3298	168,297	57	\$36,768	\$15.90
Surgical Appliances and Supplies	4134	125,840	32	\$64,136	\$20.40
Electromedical Equipment	775	41,902	64	\$16,979	\$32.10
X-Ray Apparatus and Tubs	279	8,523	35	\$1,435	\$7.40
Industry Total	8486	344,562	47	\$121,318	\$18.95

Industry Analysis

The worldwide medical device business had sales of \$190 billion in 2002, which was expected to have increased by 15% by the end of 2004.³ There are about 5177 medical device manufacturing establishments in the United States, employing about 308,614 people.^{xxvi} Wages in medical device manufacturing are roughly 20% higher than in average manufacturing jobs. Seventy-five billion dollars of medical technology is purchased annually in the US, \$175 billion globally.⁴

Notably, medical devices represent a little more than 24% of the 161 companies identified in the study. Medical devices is also responsible for employing 1,708 people in the state, which represents 18.7% of the state's bioscience related employment.⁵

³ Standard & Poor's Industry Surveys, *Health Care: Products & Supplies*, September 11, 2003

⁴ www.advamed.org

⁵ Thomas P. Miller & Associates, 12/2003

8.2 – Animal Sciences

Animal Science is the field of study involving the production, marketing, and utilization of domestic animals in agriculture, entertainment, and companionship. Animal science incorporates anything from testing the development of new medicines and therapies on lab rats, to studying the benefits of the use of animals for human companionship, to developing better animal feed.



Thirteen general divisions of Animal Sciences can be identified:⁶

- | | |
|--------------------------------------|-------------------------------|
| *Animal biotechnology | *Physiology and endocrinology |
| *Breeding/genetics | *Silage technology |
| *Animal health, ethology and welfare | *Wildlife management |
| *Food science | *Environment and housing |
| *Meat science | *Food evaluation |
| *Monogastric nutrition | *Animal products |
| *Ruminant nutrition | |

Much of animal sciences concern animal products, specifically food products. Animals account for fifty-three percent of all food consumed in the U.S.: animal products provide seventy-six percent of protein, eighty-one percent of the calcium, sixty-seven percent of the phosphorous, and thirty percent of the energy in the average American diet. Most animal products come from: beef, swine, dairy, sheep, poultry, and equine products.

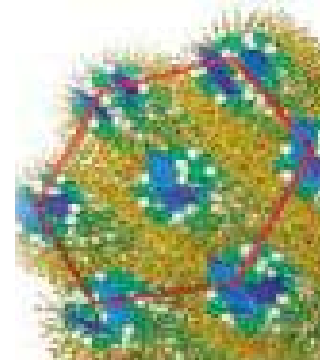
Dairy scientists, poultry scientists, animal breeders, and other scientists in related fields study the genetics, nutrition, reproduction, growth, and development of animals. Some animal scientists inspect and grade livestock food products, purchase livestock, or work in technical sales or marketing. As extension agents or consultants, animal scientists advise agricultural producers on how to upgrade animal housing facilities properly, lower mortality rates, handle waste matter, or increase production of animal products, such as milk or eggs.

Many advances in animal science have developed within the past fifty years due to the advent of computers, which have revolutionized animal production, research, and marketing capabilities. Due to this technology, alternative feed sources were identified; estrus synchronization agents were discovered; embryo transfer techniques were developed; and new growth-promoting compounds were advanced. For example, animal sciences has lead to new genetic technologies, including the genome mapping of cattle, swine, sheep, horses, dogs, mice and humans. The development of a genome map, in turn, has lead to our ability to create the field of transgenics or the insertion of DNA from one organism to another organism of a same or different species.

⁶ Kansas State University

8.3 – Biomass, Biofuels, Biomaterials and Environmental Applications

“White” biotechnology is the category of biotechnology applications for industrial purposes. Biomass, biofuels, biomaterials, and other environmental applications represent a subset of the myriad of applications of advanced biological sciences research in areas other than human therapeutics. Biomass involves strategies to improve the yield of organic material – plant and animal products – that can be used for processes such as cooking and industrial uses. Biofuel is fuel that is derived from biomass rather than petroleum.



One prevalent category of biofuel is biodiesel, which may be produced from vegetable oils or cellulose fermentation. Biomaterials are the category of materials produced using advanced biological methods, and include textiles, plastics, and paper. General environmental applications include reclamation of contaminated environments, sewage treatment, mineral mining, and oil extraction. One of the keys to developing white biotechnology is to tap existing resources – excess biomass, waste products, and inefficient industrial processes – and develop solutions to capitalize on them.

Market Size Estimation:

“More than 80 billion pounds of plastic products are produced annually in the United States. Of that, 1 billion pounds are biobased plastics. The remaining potential for environmental benefits and reduced demand for foreign oil are substantial. For example, if all plastics were made from biobased polylactic acid, *oil consumption would decrease by 90-145 million fewer barrels per year* - or about as much oil as the United States consumes in one week.”⁷ With prices around \$40-\$50 per barrel, this would amount to a savings of approximately \$4-7 billion.

Enough agricultural crop residue is produced each year to entirely replace the 700 million barrels of petroleum used in organic chemical production. **US Market size: \$30 billion.**

A recent study by the Organization for Economic Co-operation and Development (OECD) of the economic impact of increased bioethanol production estimated that the market could potentially support fifteen economically-feasible plants producing a total of 1 billion gallons of bioethanol annually. Potential direct employment gains in the industrial, transportation, and agriculture sectors were estimated at over 22,000. Estimates of total potential annual sales vary depending on the price, but range from \$1.5 – \$2.5 billion.

⁷ “New Biotech Tools for a Cleaner Environment,” Biotechnology Industry Organization

8.4 – Drug Discovery, Delivery and Pharmacogenomics

Broadly speaking, drug discovery is an industry characterized as one where the greatest opportunities exist when there is strong alignment between curiosity-driven activities and market-driven objectives. There will be a growing impetus to bring an entrepreneurial ethic and greater manageability to the research mission at both university and corporate labs so as to reduce the 12-15 year cycle time and the roughly \$800 million it costs to bring one new drug to the market.



Drug discovery and development includes target discovery and identification, lead discovery and identification, drug metabolism and toxicity, drug process and development, and application of genomics, proteomics, pharmacogenomics and bioinformatics in accelerating drug discovery and development.

Of particular value are technologies that facilitate drug delivery. Many of the newer, biotechnology-derived drugs face delivery challenges not seen in the prior generation of small-molecule synthetic pharmaceutical drugs. Novel delivery methods are required to effectively deliver therapeutic doses to their targets. These delivery systems can also benefit existing drugs, facilitating administration and improving safety and efficacy. Novel delivery methods also represent an inexpensive way to enter competitive markets. Recombinant insulin, for example, is established as the preferred treatment for diabetes. Biotechnology companies are pursuing gene therapy and aerosol delivery systems to improve on current shortcomings and gain market share without the expense of new drug development.

Pharmacogenomics examines the inherited variations in genes that dictate drug response and explores the ways these variations can be used to predict whether an individual patient will have a good, bad, or no response to a drug. In essence, pharmacogenomics is leading the drive for personalized medicine. Among the diagnostic tools used for pharmacogenomics are discrete genetic variations called SNPs. These variations can be used as a diagnostic tool for predicting a person's drug response. DNA micro-arrays are an evolving technology that make it possible to identify SNPs quickly and are becoming increasingly affordable.

Market Size Estimation:

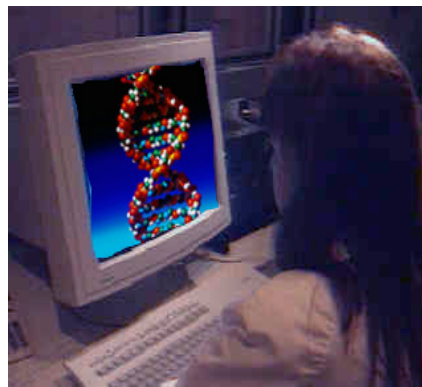
Global pharmaceutical industry sales attributed to U.S. companies in 2003 were over \$212 billion. The U.S. biotechnology industry attracted \$20 billion in investment, and Ernst & Young estimates that 2005 sales will rise 20% and exceed \$51 billion⁸.

⁸ *Pharmaceutical Research and Manufacturers of America, Biotechnology Industry Organization*

8.5 – Health Related IT (including Bioinformatics and Telemedicine/Telehealth)

Bioinformatics:

Bioinformatics is the convergence of computer science, information technology and biotechnology. The application of computer science and information technology is to manage and analyze the vast amounts of data generated from basic biological research such as nucleotide and amino acid sequences. Bioinformatics assists scientists in managing data and enables interpretation of data by presenting it in useful forms.



There are two successive elements in bioinformatics: data assembly and data analysis. Computer-assisted data management enables gathering, analysis, and representation of biological information to help scientists better understand biological processes; understand the mechanisms behind diseases; develop methods to treat diseases; and develop applications based on biological knowledge. Bioinformatics also allows researchers to perform comparative and predictive studies of biological processes. Applications of bioinformatics data analysis include prediction of protein structure, prediction of protein function, and drug target selection.

Telemedicine:

Telemedicine, telehealth and e-health are terms that are often used interchangeably. However there are some subtle differences in their definitions. Telemedicine itself can be defined as the use of telecommunication to provide diagnostic and therapeutic medical information between a patient and doctor without either of them having to travel.

Telehealth on the other hand is a more generic term to describe a wider definition of telemedicine. It is the use of information and communication technology (ICT) to deliver health services, expertise and information over a distance. However, e-Health is more broad than either telemedicine or telehealth and can be described as an emerging field in the intersection of medical informatics, public health and business that enables health services and information to be delivered or enhanced through the Internet and related technologies.

Central to all these definitions is that the use of information and communication technology, such as the Internet, is required for long distance health services delivery.

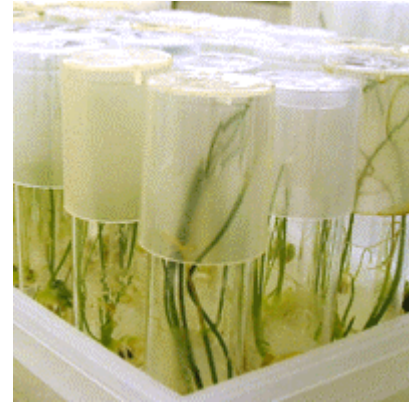
Market Size Estimation:

Feedback Research Services (FRS), a marketing firm producing a number of reports on the subject states that the current annual U.S. market for telepathology, teleradiology, and videoconferencing telemedicine systems is under \$100 million. They estimate that worldwide sales of products and services during the 1990s reached an estimated \$520 million, cumulative, through the year-end of 1996.

8.6 – Plant Sciences

Definition

Plant Science is the field of study involving the production, marketing, utilization and study of plants and plant materials. Agronomy, crop science, entomology, and plant breeding are included in plant science. Scientists in these disciplines study plants and their growth in soils, helping producers of food, feed, and fiber crops to continue to feed a growing population while conserving natural resources and maintaining the environment. Agronomists and crop scientists not only help increase productivity, but also study ways to improve the nutritional value of crops and the quality of seed, often through biotechnology. Some crop scientists study the breeding, physiology, and management of crops and use genetic engineering to develop crops resistant to pests and drought.



Due to the over inclusiveness of the field, there are many disciplines within plant sciences, resulting in numerous definitions and classifications that intersect and overlap.

Major areas of coverage include:⁹

- | | |
|------------------------------------|--------------------|
| *Physiology | *Diversity |
| *Pathology | *Genetics |
| *Environmental biology & pollution | *Taxonomy |
| *Breeding | *Crop Protection |
| *Agronomy & horticulture | *Water & nutrients |
| *Biotechnology | *Plants & medicine |
| *Algae, lichens, mosses and ferns | *Forestry |

Market Size Estimation:

Due to the expansive nature of this field, it is difficult to pinpoint an accurate market size estimate. However, one way to discuss market size is through the calculation of one specific sub-field within plant sciences: nutraceuticals. The U.S. market for nutraceuticals, or foods that are enhanced with vitamins, herbs and nutritional supplements, was \$46 billion in 2002, and is expected to grow to more than \$74 billion by 2007.¹⁰

⁹ <http://www.csa.com/>

¹⁰ *Business Wire*, November 15, 2004

9 – Recommendations

Table 25 below outlines the “Big Ideas” and the “Fundamental Actions,” and which Hot Teams contributed to which recommendations.

Table 25 - Kansas Road Map Recommendations: Big Ideas and Fundamental Actions

	Initiative	Hot Team Contributions
Big Ideas	1.) Kansas Institute for Comparative Health (including <i>Statewide Telemedicine Delivery</i> and a <i>Statewide Cancer and Oncology Strategy</i>)	- Drug Discovery - Health-related IT
	2.) Fusion Center for Animal Health and Food Safety (including <i>Monitoring and Managing Biological Risk</i>)	- Animal Sciences - Health-related IT
	3.) Kansas Center for Biologically-Inspired Materials	- Advanced Materials - Biomass & Biofuels - Plant Science
	4.) Kansas Bioproducts Initiative (including the <i>Statewide Biofuels Project</i> and the <i>Neutraceuticals Project</i>)	- Plant Science - Biomass & Biofuels
Fundamental Actions	1.) The Statewide Workforce Continuum: <i>Developing Skills, Competencies and Future Talent</i>	All Hot Teams
	2.) Awareness Campaign: <i>Positioning Kansas’ Assets</i>	All Hot Teams
	3.) Statewide Funding Team: <i>Gathering Resources for Competitiveness</i>	All Hot Teams
	4.) 3C: <i>Catalyzing Capital, Commercialization & Critical Mass of Growth, Mature Companies</i>	All Hot Teams
Enabling Factor	Statewide Collaboratory: <i>Accelerating Digital BioScience Connectivity</i>	- Health-related IT - Drug Discovery

Big Ideas and Fundamental Actions:

Each of the opportunities can be categorized in different ways - from cutting edge product developments, to value-added services and activities, to mechanisms for medical breakthroughs – however, all require the engagement and connectivity of people and institutions across the region. Similarly, each target area will have a myriad of regional impacts and outcomes, including increased employment in the region. New vendors, suppliers, service providers, and related companies will emerge as will a variety of measurable economic consequences and intangibles such as enhanced relationship building and leveraging of existing knowledge.

9.1 - Big Ideas for Global Competitiveness:

1.) Kansas Institute for Comparative Health

"Comparative medicine is a discipline in which animals are studied to discover the mechanisms of human disease. Such comparative studies are critical to move medical research from the laboratory bench to the patients' bedside and develop rational prevention and treatment for both human and animal diseases."

- Johns Hopkins School of Medicine

Initiative:

The initiative proposes creating the Kansas Institute for Comparative Health, a therapeutic and diagnostic agent research and development funding agency under the Kansas Bioscience Authority (KBA). The Institute would have a special focus on cancer. The Institute's mission would be to financially support research and development on medical product discovery, product development, and clinical trials, including new, improved or individualized therapies and diagnostics. In particular, the Institute would award grants or contracts to aid in the discovery of new medicines, diagnostics or other therapeutic modalities, the preclinical development of such new products, and the beginning of clinical trials of these new products. Funding from the Institute would require collaboration between basic and clinical scientists on targeted, medically important projects as well as collaboration between academia and industry for the commercial development of new products. Whenever possible, development contracts would specifically target companies and universities in Kansas for the completion of preclinical and clinical research. Development could include drug candidates from sources outside of the state of Kansas (for example, an orphan drug discovered, but not developed by, a large pharmaceutical company). Funding for clinical trials work would require extensive partnering with private sector companies.

Description:

The purpose of the Institute would be to give Kansas a competitive edge in the discovery and development of medical therapeutics and diagnostics. This funding program would:

- Expand biomedical research capacity by supporting core facilities in genomics, proteomics, and bioinformatics at the state's two largest research universities,
- Stimulate collaboration between basic research scientists and clinical research scientists from Kansas's universities and bioscience businesses,
- Give Kansas companies and entrepreneurs a competitive edge in the race to develop new therapies and diagnostics, by partially subsidizing both the discovery and development processes for products developed in Kansas.

The availability of funds for both discovery and development research would help make Kansas an attractive site for new and emerging bioscience businesses. This new funding program,

coupled with the proximity of the Stowers Institute, could potentially make Kansas a national hub for discovery, and in particular, for development of new drugs, diagnostics and other therapeutic approaches.

Outcome:

Collaborative research grants could result in potential new products or services, invention disclosures, patents, federal research dollars and accumulation of expertise in selected research areas. Product development contracts to fund preclinical drug development in Kansas could increase the alliance between Kansas researchers and Kansas development firms. Furthermore, these contracts should increase the number of licensable products emerging from the state's efforts and help establish the state as a national node for early stage medicinal product development. Creation or enhancement of biomedical research core facilities would provide strong support to the drug discovery process and would enhance the ability of the state's universities to attract both federal funding and high-caliber faculty. Assistance provided to Kansas start-up companies to bring products to early stage clinical trials would directly enable the formation of new companies dedicated to providing therapeutic and diagnostic solutions to current health care issues.

Statewide Cancer and Oncology Strategy

Initiative:

This initiative proposes to develop a statewide cancer and oncology strategy in support of the efforts under the Kansas Masonic Comprehensive Cancer Center led by Dr. Roy Jensen. The long-term effort would be to have the Institute of Human and Comparative Health act as an advocate and integrating force for the expansion and extension of oncology-based discovery and development.

Description:

The commitment to design, construct and operate a National Cancer Institute comprehensive cancer center located in Kansas City and tied to the University of Kansas Medical Center requires statewide adoption and utilization of the services and programs offered through this high-profile initiative. The recently released National Institutes of Health Road Map explains that the future investment of resources by entities such as the NCI will encourage greater collaboration across multiple institutions and geographic interests. Therefore, the Institute and the state of Kansas should seek to accelerate Dr. Jensen's application and successful award of the comprehensive designation by organizing and integrating research, patient base information, and other elements of the Kansas Bioscience and Innovation Road Map targets and tactics.

Outcome:

An important outcome for the Institute and the Statewide Cancer Strategy will be the formation of a clinical trial network and active integration of development and delivery from the results of new clinical programs and drug regimens to battle specific cancers related to Kansans.

Statewide Telemedicine Delivery:

Initiative:

The initiative proposes to develop a fully-integrated, statewide telemedicine and disaster-response infrastructure. The long-term goal would be to develop a health care infrastructure that could serve as a national model for access to health care, loss-prevention, and community sustainability.

Description:

This initiative would take a multi-faceted approach to enhancing the economic vitality and health of Kansans, particularly in rural areas. Of primary interest would be the ability to provide high-quality medical services in a timely and cost-effective manner to remote areas. This is crucial for a small community to attract and retain businesses and their associated employees.

Outcome:

One result of this initiative could be to make Kansas a more cost-effective location for businesses to locate. Also, many business opportunities could emerge to capitalize on business opportunities to scale the initiative and role out to other regions. Based on existing strengths, an opportunity exists in the area to develop new innovative business services that deliver solutions to physicians and patients while serving as a national model for efficient delivery of high-quality health care to urban and rural areas alike.

2.) Fusion Center for Animal Health and Food Safety

Initiative:

Kansas would establish a Fusion Center to enhance its reputation and become a global hub for the advancement of animal health and food safety knowledge and technology. The Fusion Center would become recognized as an institution of excellence that provides direction, education, advocacy, research collaboration, and support. To help individuals and businesses in Kansas be successful, the Fusion Center would seek to commercialize food safety and animal health research and technologies.

Description:

Food safety represents an increasingly important area of the Kansas economy. As a supplier of wheat, meat, and a range of other food products, Kansas' health and wealth depends, in part, on food safety. Similarly, the health and productivity of animals used in production agriculture has a tremendous impact on the state's economy. Currently there is an unmet need to bring together industry, academic, and government expertise for the purposes of (a) synthesizing informational products from existing resources on animal health, food safety, and cross-cutting issues and (b) developing concerted strategies to commercialize key intellectual property.

Outcome:

Animal health and food safety are crucial to the health of the international economy, as recent health scares such as mad cow disease, hoof and mouth disease, and tuberculosis demonstrate.

Monitoring and Managing Biological Risks for Human Benefit:

Initiative:

The initiative proposes to identify, model and predict the potential spread of emerging diseases, agricultural pests, and biological threats across the United States and beyond. The initiative also proposes to integrate its models and predictions with social system information (population, economics, etc.), and to provide decision makers in the agricultural, economic, natural resources, health and security arenas with an early warning system.

Description:

This initiative is unique in that it develops a predictive early warning system across disease, invasive species, potential bioterrorism and other biological phenomena, rather than a post-facto response. The appropriate preventative measures can be targeted based on risk assessment, thus enabling resources to be allocated efficiently in terms of cost and efficacy.

Outcome:

Direct economic benefits will occur as a result of having predictive models that provide information required to manage risk and make proactive strategic decisions that benefit human health. Such information is of great value to governments, companies, individuals and economies impacted by potentially harmful events. As an example, such a system would help

mitigate devastating losses that result from the spread of agriculture plights due to the spread of invasive pests or disease, or human diseases spread by insects and migratory species, as well as other specialized bioterrorism catastrophes.

In addition, the foundation for the intellectual and technical resources already exists to develop a new service industry in Kansas. Such an industry would assimilate the associated data, perform required analysis, make projections, and summarize results for customers to make strategic business decisions. This potentially could build on the international research reputation of the Biodiversity Institute to build a global service industry based in Kansas.

Leveraging the Kansas City Life Science Institute's Animal R&D Project

Initiative:

Through the results of the Kansas City Area Life Science Institute assessment conducted in 2004, the identification of animal research, development and commercialization as a prominent target of opportunity resulted in the KCALSI and the Greater Kansas City Chamber of Commerce advancing a far-reaching regional initiative. With the formation of the statewide Fusion Center, it is proposed that the state of Kansas and Kansas City create a memorandum of understanding for future collaboration.

Description:

The Fusion Center advances the concept that agriculture is an important economic driver for the 21st century and that animal disease, food safety, and other related interests are important Kansas distinguishing and unique ingredients for a competitive long-range opportunity. At the same time, many of the assets and infrastructure for the Fusion Center are based in the multi-county region around Kansas City. The industry and sector knowledge that Kansas City offers should be linked with the assets found through rural and agriculturally-based communities in various parts of the State.

Outcome:

The desired outcome by leveraging the relationships, networks, and asset-infrastructure between the statewide objective of the Fusion Center and that of the regional endeavor in Kansas City is a more efficient and effective promotion of the "Kansas" brand for animal research and food production that has long-been globally recognized.

3.) Kansas Center for Biologically-Inspired Materials

Initiative:

This initiative would be a collective effort to integrate elements from three original Hot Teams (Advanced Materials and Medical Devices; Biomass, Biofuels, Biomaterials, and other Environmental Applications; Plant Sciences) to establish a Kansas Center for Biologically-Inspired Materials and Technology (KCBIMT).

Description:

Biologically-inspired materials include:

- Biologically-derived materials made from renewable agriculture commodities for industrial, textile, military, and medical and pharmaceutical uses,
- Biomaterials for medical and pharmaceutical applications, and
- Biomimetic and similar materials which are inspired by the structure, property, or function of living tissue for use in a variety of industries, including aerospace, military, and medical devices.

Kansas has a strong national reputation in agriculture, engineering, aviation and materials science, and Kansas has emerging strengths in biosciences, bio-based materials, bio-products and biomedical product development.

Outcome:

Significant opportunities exist for diversifying Kansas' key agricultural crop commodities, not least of which includes using biochemical precursor compounds in plastics, binders and glues, and other advanced materials. According to a recent review by the BioScience Initiative, more than 80 billion pounds of plastic products are produced annually in the United States. Of that, 1 billion pounds are biobased plastics. The potential benefits in terms of the environment and in terms of reduced demand for foreign oil are substantial (see section 8.3). For example:

4.) Kansas Bioproducts Initiative (including Statewide Biofuels Project)

Initiative:

This initiative proposes creating a Center of Excellence for Bioproducts. The Center would work to enhance the Kansas economic base and provide development opportunities in rural Kansas. Bioproducts, as defined here, are those created from animal- and plant-based resources such as agricultural crops and crop residues, forestry, pastures, and rangelands. Bioproducts includes biomaterials, biochemicals and biofuels. Additionally, a special effort will be made on Biofuels. Kansas has significant existing resources and companies working in ethanol and its co-products, and Kansas is an increasingly important player in alternative fuel production. Companies are also working closer towards a commercially-viable cellulose-based fuel product.

Description:

The engine to develop new technologies and demonstrate their efficacy would result from the formation of a vibrant Consortium and Center built upon the existing research base at Kansas State University and Pittsburg State University. A team would apply an interdisciplinary strategic approach to promote widespread use of biobased products utilizing Kansas agriculture commodities to meet future national and environmental needs. This center would be built on the existing strong research foundations at Kansas State University with engineering, agricultural materials processing, and grain science capabilities, as well as at Pittsburg State University (including the Kansas Polymer Research Center, or KPRC - a world leader in the field of oil-based chemicals and materials). The champions would be researchers at PSU and KSU who are already deeply involved in the effort. The organizational home could be a cooperative effort including both universities, but possibly housed at the Bioprocessing and Industrial Value-Added Program (BIVAP).

Outcome:

Outcomes include the development of agro-plastics (plastics that are composed of 50% straw). This technology could provide farmers with large new markets for wheat straw. In 1994, there were 61,771,000 acres of harvested wheat straw in the United States. The plastics market is large enough to use significant amounts of biomass. Since the current market uses approximately 3.5 million tons of filler each year, this could translate to a \$140 - \$210 million market.

Another promising technology is Biobased Adhesives for Wood Particleboard (currently being Developed at KSU). A large market exists for the various adhesives and resins used to make plywood and particleboard for construction and furniture. About eight billion pounds of adhesives and resins are used annually in the U.S, most of which are produced from petroleum-based and synthetic chemicals. This includes about four billion pounds of urea formaldehyde-based adhesives, which are mainly used for particleboard and plywood for interior application. Formaldehyde emission has been an environmental issue for some states and countries, and formaldehyde has recently been banned in adhesives sold in California. Several chemicals have been recommended as alternatives to formaldehyde-based resins, but none of them have yet met the standards set by the regulations. Soy products (flour, protein, and oil), on the other hand, have shown great potential for adhesive applications. Utilization of soybeans or other crop based

proteins and oils for adhesives could reduce or replace petroleum-based and synthetic chemical based adhesives, and ease environmental pollution from chemicals.

Nutraceuticals:

Initiative:

This initiative proposes building a center of excellence for healthful crop production, processing, and marketing in Kansas. The aging population of the U.S. and the consequent growing concern over health has created a major opportunity to establish a new market and strategy to improve Kansas crops by focusing on maximizing healthful traits, either through selection of natural inherent compounds found in these crops such as antioxidants, fibers, vitamins, oils, and phytohormones (called nutraceuticals), or by introducing traits through genetic engineering such as pharmaceuticals (prescription drugs) or bacterial or fungal nutraceuticals (naturally occurring healthy compounds).

Description:

In the nutraceutical industry there is a new, innovative emphasis on whole plant components (ground leaves, fibers, flours, or concentrates) that possess specific health-prompting compounds. There is also a growing interest of the pharmaceutical industry to engineer crops and horticultural plants to produce complex medicines. The Kansas economy would greatly benefit from new strategies of implementation, marketing, and commercialization of crops targeted towards specific nutraceutical and biopharmaceutical products.

Outcome:

According to the National Nutraceutical Center at Clemson University, the nutraceutical foods, pills, and supplements industry have grown to an \$86 Billion industry in the U.S. over the last five years. Current income from the sale of all crops in the state of Kansas equals only \$4 billion dollars. A focused effort to improve crops for nutraceutical, biopharmaceutical and industrial biomaterials over 10 years could possibly result in an increase of crop sales of 25% (an additional income of \$1 billion). Additional value-added processing of products will add additional income to the state. The total potential market for all bio-products is sufficiently large to support a sizable industry sector if it can efficiently convert some of the current supply of Kansas agri-products into higher-value industrial intermediates or end-use products. The limitation appears to be technology rather than local, national or international market potential. Investment now into new crops for industrial and healthful purposes (beyond traditional food markets) could ensure the potential for Kansas agriculture to profit from crop production well into the future.

9.2 - Fundamental Actions/Enabling Factor:

1.) The Statewide Workforce Continuum: Developing Skills, Competencies and Future Talent

Surveys, interviews, summits, and Hot Team members identified the need to coordinate the pipeline of skills, competencies, and training around the end-user of the bioscience industry. Because workforce is needed with different skills and competencies at different times along the innovation process, a Continuum consisting of public and private sector providers and resources should be organized to respond to current and future demand. The Continuum would map the skills and development around the core, supportive, and transformative competencies that drive the biosciences cluster, as well as smooth the way for building critical mass.

2.) Awareness Campaign: Positioning Kansas' Assets

The Awareness Campaign would have both an internal and an external focus. The internal focus would be on increasing awareness among current and future stakeholders of the importance for a thriving bioscience industry – impacting both the economic and societal benefits for Kansans. This Initiative could include, among other activities, the following: awareness events at Technology Celebration Days, Regional Forums on Progress, an annual performance metrics report, partnerships with high schools on career pathways, and popular media articles-editorials regarding the State's strengths and opportunities. The external focus would be on leveraging networks of alumni from Kansas academic institutions to increase awareness of the State's scientific, technological, and entrepreneurial opportunities for future collaboration, investment, and a 'return home' strategy.

3.) Statewide Funding Team: Resources for Competitiveness

The Funding Team's mission would be to increase the investment of federal dollars into the State's academic institutions, partnerships, and ultimately the requirements around the Hot Teams' centers, initiatives, and institutes. The Funding Team's goals would include:

- Identifying the process by which Kansas could advance over the next three to five years from an EPSCOR state to one of the top 25 states receiving federal funding for science, technology and innovation,
- Inventorying, identifying, and linking all of the available resources from the private sector, industry, and philanthropy that are emerging as new investors in science and technology along the discovery and development stages,
- Organizing a team of grant-writers, application managers, resource departments and leading committees of Principal Investigators to ensure an increased flow and size of successful funding requests,

- Forming ‘leveraging networks’ to seek out multi-million dollar, multi-year contracts, grants, and investments in select areas of recruitment and attraction of key faculty, research and development teams.

4.) “3C”: Catalyzing Capital, Commercialization & Critical Mass of Growth, Mature Companies

The “3C” would entail:

- Catalyzing the capitalization of entities at the formation and growth stages,
- Commercializing technologies among academic, industry, and technology syndicators in and beyond Kansas,
- Recruiting, attracting and incentivizing growing companies, mature companies, vendor-supplier chains, and expertise to locate in Kansas as a part of their innovation agenda,
- Leveraging Offices of Technology Transfer, the National Institute for Strategic Technology Acquisition and Commercialization, Regional Centers, National Corporate representation, and ties into a cohesive roundtable of expertise, vetting, and co-investing

Enabling Factor:

Statewide Collaboratory: Accelerating Digital BioScience Connectivity

The purpose of the Statewide Collaboratory would be to:

- Continue the successful electronic linkages that were formed during the Hot Team process among academic, industry, regional economic and industry organizations, and public sector agencies,
- Connect Principal Investigators to each other for future grants, contracts, and knowledge sharing on discoveries and development. In turn, connect Principal Investigators and their Teams with Industry, Commercialization and General Applied/Translational Interests,
- Serve as a Statewide Clearinghouse for Research, Enterprise, and Branding-Positioning Targets and Planning,
- Serve as the backbone for sustainable connectivity among the Implementation Teams and Statewide Mechanism-Organizations Responsible for Execution.

9.3 - Other Opportunities for Further Consideration:

Vaccine Stabilization and Macromolecule Laboratory: An Opportunity for Future Commercialization in Human Health

Initiative:

Increasingly the nature of viral infections and the distribution of new viruses leaves U.S. citizens exposed to strains of diseases requiring updated research and vaccinations. The on-going challenge in the battle to combat diseases necessitates the stabilization of molecules that are constantly being identified as potential responses to West Nile, Hepatitis, Rotavirus and other vaccines for both human and animal health benefit.

Description:

The distinguished career of Dr. Russell Middaugh and his team of experts offers Kansas an opportunity to leverage national and global knowledge in the future of vaccine research, development and commercialization. The creation of a new research center offers the State and its multi-disciplinary capabilities to align around vital health and homeland security challenges, as well as to link with several other U.S. regional efforts underway in the lucrative commercialization of vaccine protocols and production.

Outcome:

While not a part of the final process for identification and prioritization during the Hot Team phase of the Road Map, the opportunity offered by Dr. Middaugh's concept for vaccine stabilization should be given further consideration and examination as a vital part of the Institute and other efforts within the biosciences.

10 – Conclusion

10.1 - Hot Team Implementation Timeline and Critical Next Steps:

Table 26 - Hot Team Implementation Timeline

Immediate (0-18 months)	Near-term (18-36 months)	Long-term (36+ months)
Big Idea #1: Kansas Institute for Comparative Health (including <i>Statewide Telemedicine Delivery</i> and a <i>Statewide Cancer and Oncology Strategy</i>)		
Inventory assets along disease categories. Partnering within the Institute.	Recruitment of global partners. Identification of priorities for test-bed, pilots.	Production, spin-off, commercialization of new product. 100% utilization rate by service providers, end-users, deployment
Big Idea #2: Fusion Center for Animal Health and Food Safety (including <i>Monitoring and Managing Biological Risk</i>)		
Recognition by in-state and global research partners. Partnering within the Fusion Center.	Launch of Center sub-category programs. Identification of priorities for test-bed, pilots.	Attraction of global food safety collaboratory, implementation of a warning system. 100% utilization rate by service providers, end-users, deployment.
Big Idea #3: Kansas Center for Biologically-Inspired Materials		
Attention to 2-3 specific products, markets	Creation of product development ‘teams’	Recognition as the location for innovation, creative materials. Proven commercialization results.
Big Idea #4: Kansas Bioproducts Initiative Statewide (including the <i>Statewide Biofuels Project</i> and the <i>Neutraceuticals Project</i>)		
Establish prioritized agenda of market analysis, targets. Form Biofuels Working Group and Neutraceuticals Working Group	Recruit industry market product teams. Position Biofuels and Neutraceuticals projects as national agenda-setters	Initiate Commercialization process in enterprise development stage, create new biofuels and nutraceuticals companies.
Fundamental Action #1: The Statewide Workforce Continuum		
Organize Continuum ‘Hot Team’ among key providers	State, federal, industry funding successfully captured	Successful realignment of education, training, provider, and end-user networks
Fundamental Action #2: Awareness Campaign		
Coordinate and prioritize the awareness agenda	Create and launch awareness campaign, establish performance metrics	Take advantage of increased visibility and positive image to foster increased growth, new company creation
Fundamental Action #3: Statewide Funding Team		
Inventory top funding priorities from implementation agenda	Create and launch Funding Team	Promote Kansas moving from EPSCOR to New Ranking
Fundamental Action #4: 3C: Catalyzing Capital, Commercialization & Critical Mass of Growth, Mature Companies		
Implementation of legislative agenda for the commercialization focus	Attraction of industry and entrepreneurial risk-taking new dollars, skills	Completion of \$100 million in startup, growth and mature stages of investment
Enabling Factor: Statewide Collaboratory		
Enshrine electronic infrastructure created from the Hot Team process. Devise mechanism to encourage principal investigators to share knowledge, incentivize cooperation.	Develop structure and methodology for matching grant management/co-investments, secure funding. Assist with branding and positioning efforts.	Facilitate the formation of lasting partnerships between industry, principal investigators, academia, and government. Position the collaboratory as a clearinghouse for research and intellectual property.

10.2 – Closing: The Imperative to Implement

For over five years, several organizations and individuals have been working diligently to advance Kansas' competitive capacities in biosciences. The successful legislative package creating the Kansas BioAuthority was the capstone to the objective of accelerating the state's competitiveness nationally and globally. All along, the efforts underway in regions throughout the state have increased the profile of unique and distinguishing features on which Kansas could promote the biosciences, including human and animal research, discovery and delivery of health care services, and an improved quality of life for citizens and future generations. The promotion of a bioscience agenda has been quite inclusive, suggesting that the biosciences can produce economic and entrepreneurial benefits for all Kansans, both in urban and rural communities.

The Road Map process has produced specific and focused priorities on which to target resources and energies, as well as an increased awareness of the assets and infrastructure that comprise a statewide inventory and capacity to innovate. The Road Map process has also accelerated the building of strong relationships and networks among researchers, investigators, capital and funding resources, and economic development institutions. By utilizing the 'Hot Team' approach to hastening the identification and drafting of tactics that must be executed, Kansas now has a plan that is clear, concise, and able to be acted upon immediately. Over 500 individuals have contributed to creating a portfolio of immediate, near-, and long-term investments of resources (time, reputation, and money), with the goal of "leap-frogging" the competition, and making Kansas a global bioscience hub or node.

What remains is an imperative to implement: ineffective and inefficient activities must be eliminated, sustainable results must be catalyzed, and innovation must be fostered and coordinated statewide.

Although some of the choices which were made during the 'Hot Team' process may lead to the incorrect perception of a win-lose dynamic, it is important to recognize that no institution or organization was left out of the process for the identification of the Big Ideas and the Fundamental Actions, and no counsel or advice was excluded from any source. Rather, the Road Map represents a win-win proposition, produced by Kansas and for Kansans – and a mandate now exists for its implementation across academic and geographic boundaries.

Therefore, it is critical to the successful implementation of the Road Map that the principles and tactics found throughout this document be adopted as core mission statements and operating procedures in each and every organization tied to the creation and execution of the plans. By word and by action the Road Map will become a profound response to the original charge given by legislative and public sector leaders: to make Kansas a successful global competitor in the bioscience economy by 2010.

References:

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- ^{xviii} PricewaterhouseCoopers MoneyTree
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- ^{xxii} National Science Foundation Science and Engineering State Profiles, 2003
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- ^{xxiv} "Vital Assets: Federal Investment in Research and Development at the Nation's Universities and Colleges," RAND RaDiUS, 2004
- ^{xxv} Dun & Bradstreet
- ^{xxvi} US Census Bureau, 2002. Medical device manufacturing is defined here as including NAICS codes 334510, 339112, 339113, 339114, and 339115.