Identifying and Strengthening Our Bioscience Assets and Opportunities

Kansas Center for Biologically-Inspired Materials and Technology
ADVANCED MATERIALS CROSS-CUTTING HOT TEAM BUSINESS PLAN

I. Describe the initiative(s):

This collective effort is to integrate materials 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). Biologically-inspired materials include 1) biologically-derived materials made from renewable agriculture commodities for industrial, textile, military, and medical and pharmaceutical uses, and 2) biomaterials for medical and pharmaceutical applications, and 3) biomimetic and similar materials which are inspired by the structure/property/function of living tissue for use in a variety of industries including aerospace, military, and medial devices. Kansas has a strong national reputation in Agriculture, Engineering, Aviation and materials science, and Kansas has emerging strengths in Biosciences, biobased materials, bioproducts and biomedical product development. Historically, there are natural connections:

1. Many advances in biomaterials and medical technology were developed in the aerospace and defense fields and adapted for specific uses in biomedical products.

2. Identifying material and product needs, ensuring access to raw materials, and performing basic through applied research, materials development, materials characterization, product development, and commercialization of diverse bioproducts requires strong interdisciplinary interaction in areas identified as Kansas strengths.

3. 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 remaining potential for environmental benefits and reduced demand for foreign oil are substantial. For example, if all plastics were made from biobased polylactic acid, 90–145 million fewer barrels per year would be consumed—or about as much oil as the United States consumes in one week." 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. Utilization of grains and seeds from crops for non-food, high value products and the resulting residue for biofuels would revolutionize the crop industry in the U.S. and help ensure a continued demand for our primary crops.

Kansas' strengths in advanced materials, polymers, nanotechnology, design, material and structural characterization, manufacturing, and avionics require many of the same skills and resources needed for development of new industrial applications and biologically-inspired devices. KCBIMT will be coordinated with KTEC (or another designated Biosciences Authority) and will:

- **Create new economic opportunities** for Kansas through development of new industries in bioproducts and biologically-inspired devices, serving as value-added customers to enable growth in existing industries in agriculture, materials science and engineering.
- **Promote commercialization** of intellectual property and innovations in the agricultural, biologically-inspired devices, biomaterials, bioproducts and advanced materials fields by providing incentives such as shared research facilities, business incubators, collaboration with scientific community, business development assistance, marketing services.
- **Generate and endorse knowledge** sharing among professionals from academia, industry, private institutions and the life science community throughout the state through Technology Opportunity Recognition Forums.
- **Provide educational opportunities** for state professionals and students to learn about advanced biologically-inspired materials, funding opportunities, and general entrepreneurship to help encourage formation of start-up bioscience companies and attract existing bioscience businesses to Kansas.
- **Increase global awareness and recognition** of advanced biologically-inspired materials and technologies, bioproducts and services developed and manufactured in Kansas.
- **Encourage growth** by linking product/service developers with companies that seek to commercialize these processes.
- **Help to coordinate policies** in Kansas universities regarding start-up spin-off companies and intellectual property.
- **Encourage the collaborative pursuit of** funding and investment, both from federal sources and private enterprise.

Two preproposals describing the core activities within the KCBIMT initiative were submitted in March 2005 to the 2005 NSF EPSCoR Major Initiatives to Improve Research Infrastructure program by teams of researchers from KSU, KU, WSU, PSU and industry (see Appendices A1 and A2). Strengths of current state centers of expertise proposed as initial partners are addressed in Appendix B1; examples of current projects underway in the biologically-inspired materials area are given in Appendix B2.

II. Describe the long-term goal:

The long-term goal of the KCBIMT initiative is to enable sustainable commercialization of biologically-inspired materials and devices, bioproducts, and utilization of Kansas' agricultural base crop commodities for industrial, textile, military, medical and pharmaceutical consumer demanded products. This will maximize the value-added chain of Kansas products, thus growing bioproducts and biologically-inspired device industries while supporting the continued success of other Kansas industries. This goal will be accomplished by facilitating collaborations among strong current disciplines (agriculture, engineering, material science, medical) within the State and educating both existing and new work forces in the field. This initiative will bring a significant amount of additional revenue to the state, attract federal research dollars, spawn federally funded centers of excellence in biologically-inspired materials and technology, increase the number of high-tech jobs in the field and in traditional Kansas industries, create new tax revenues from developing biologically-inspired materials and technologies, develop and expand

markets for value-added agricultural products, and enhance the educational base of the state. From a state political perspective, it will be important to support the current Kansas industry base as well as the biosciences through the KEGA initiative.

To prosper, Kansas must be nationally and globally recognized as one of the leaders in the development of new technologies. The proposed center will help to create the infrastructure that will ensure future success. It is important to develop more Kansas industries that can utilize the advanced materials developments manufactured in Kansas. While the sale of advanced materials to companies outside of Kansas generates revenues, the development of Kansas companies using these materials in manufacturing products will drive greater revenues and provide substantial and stable long-term job growth in the state. Such benefits are magnified if the raw products for the materials utilize Kansas' agricultural commodities. Future assets required for success in this endeavor are education, communication to facilitate collaborations and invention development, and initial support for start-up and existing companies to grow and prosper in the biologically-inspired materials and technologies fields.

III. Describe impact on the four phases of the innovation lifecycle (conception-formation-growth-maturity):

The proposed initiative will catalyze positive churn in the innovation lifecycle in both the advanced materials and the bioproducts and biologically-inspired devices fields. Collaborations in advanced materials will be strengthened and will grow rapidly since this field is well established and globally recognized in Kansas. Our state has established world-class scientists in bio-materials for industrial applications (KSU and PSU), advanced materials characterization (WSU), and nanotechnologies (KSU), and emerging or recently hired world-class scientists in biomimetic and similar biologically-inspired materials (KU). Return on investment for these advanced biologically-inspired materials will be immediate, whereas return on investment in biologically-inspired technology and devices will require some time for collaborations to grow and prosper. Once collaborations are initiated, this field will result in the formation of new companies, expansion of current companies, and formation of new product divisions in existing larger companies. These new and expanded entities will grow and mature because of the availability of highly skilled engineers and scientists, manufacturing facilities, and skilled manufacturing workers. The developments made in biologically-inspired materials will initially justify the investments in this area and support the existing industries, and the tremendous growth potential of the bioproducts and biologically-inspired device industries fully justifies the risk in this area.

Each of the four phases of the innovation lifecycle exists in Kansas. With enhanced coordination, we should be able to accelerate the rate of transition through the four quadrants.

1. Formalization and funding of research partnerships will foster more interdisciplinary scientific interaction, resulting in the conception of new ideas and approaches.

2. Formation of new enterprises will derive from business analysis and successful capital attraction. For instance, formation of several biobased adhesives, composite materials, and polyurethane plastics are currently underway.

3. Innovative growth will result from increased commercial and industrial partner participation, which will, in turn, provide capacity for more research and promote cross-pollination of ideas between partners. Growth of existing businesses, such as ICM and Pinnacle Technologies, should be the first priority, followed by recruitment of outside companies (like Iogen) to locate a facility in Kansas.

4. Mature innovation will lead to spin-off of new technologies and companies to commercialize these technologies into products, thus producing jobs, economic development and new tax revenues from prospering companies. Maturity implies a slow down in growth rate. However, help for these companies to expand into linked enterprises should help start the cycle over again.

Examples of possible technologies and products are:

- biobased adhesive and resin technologies for widespread industrial applications (foundry, child-safe glue and color paints, wood veneer and particle board, low density fiber board and packaging and labeling);
- electrically-active metal foams (synthetic bone grafts, implant attachment, embedded sensors);
- light-weight yet strong soft materials, gels and nanocomposites (soft tissue implants, artificial muscles, flexible armor);
- novel biodegradable composite materials (tissue engineering scaffolds, dental materials, artificial skin);
- strong and still materials (bones, limb replacement);
- biocompatible and biodegradable implants, sensors and systems;
- biologically-inspired devices and medical devices (novel hearing implants, medical sensors, laboratory devices).

Descriptions of some current collaborative research projects underway in these areas are given in Appendices B1 and B2.

Furthermore, Kansas has excellent leadership and technical skills in the modification and improvement of wheat, soybeans, corn, and sorghum varieties. The current activities focus, as they should, on the primary markets: Food and Feed. The use of these crops in other applications such as industrial non-food uses is fairly new. If the use of crop components for industrial applications expands, then a significant effort needs to be launched to identify needed traits and develop crops with these traits. Crop improvement teams need to be aligned with research efforts underway to identify and develop new products from crops. As a new process is identified, then the following steps should be implemented to develop crops specifically designed to be used in these processes:

1. Biochemical analysis and determination of the plant compounds critical to a new application, such as specific proteins, lipids, starches, sugars, phenolics, etc.

2. Characterization of the range and genetic control of compounds of interest within the cultivated varieties of the crop.

3. Testing and verification of variants of these compounds for performance improvement.

4. Development of a crop improvement program focused on improving the production of the identified compound. This can be traditional selection or genetic modification via recombinant DNA. If the crop, or promising germplasm within the species, is not currently grown in Kansas, a significant part of the breeding program may be adaptation to Kansas growing conditions. The improvement program will also determine the extent to which environmental factors influence the expression of the valuable plant compounds in the crop.

5. Development of a crop production, delivery, and processing system to ensure isolation from traditional commodity marketing systems.

IV. Describe impact on the innovation attributes (intellectual capital, human capital, financial capital, role of proximity, and social capital):

The proposed initiative will resolve the gap between the strong industries in Kansas (agriculture, engineering, materials science, medical) and the emerging Biosciences field. Promotion and enhancement of advanced materials with the bioproducts and biologically-inspired device fields will more effectively use the human and intellectual capital currently existing in Kansas by:

- Encouraging knowledge transfer by facilitating specialized "Technology Opportunity Recognition" Forums to discuss potential growth areas in bioproducts and biologically-inspired materials or devices. These forums will identify areas for research investment and growth by bringing together industry, academia and potential entrepreneurs to form collaborations crossing traditional disciplines to enable enhanced research infrastructure and economic development in Kansas.

- Endorsing knowledge and intellectual property creation by providing competitive funding for biologically-inspired materials and technology, bioproducts, and biomedical product research and development.

- Fostering existing and new companies to develop novel biobased products, biomedical products and biologically-inspired devices, especially through the use of advanced biologically-inspired materials, leading to increased job opportunities and a stronger Kansas economy.

- Promoting education of the public, educators and students on bioscience and its role in growing the Kansas economy.

KCBIMT will build human and intellectual capital in the biosciences by assisting Kansas engineers and scientists in learning about special materials and design requirements in the bioproducts and biologically-inspired device fields, promoting entrepreneurship education inside and outside of universities, and promoting industry and academia opportunities available in collaborative federal research. Loosely affiliated academic expertise is not currently being utilized in support of the emerging bioscience industry as a catalyst for economic growth. Kansas State University (KSU) and Pittsburg State University (PSU) currently have several programs targeted at utilizing crop components for industrial applications. These programs include materials experts, chemists, engineers and geneticists. The University of Kansas (KU) in Lawrence has growing programs in Bioengineering, Biophysics, and Technology Entrepreneurship, with ten bioengineering faculty and two new open positions with searches in progress. One position is for a nationally recognized director, who will facilitate development of additional positions and lab space on the Lawrence and Kansas City Medical Center campuses. KU aerospace engineering offers new and existing faculty who are experts in advanced aerospace materials, adaptive and intelligent structures and design. Kansas State University (KSU) faculty have expertise in nanomaterials and composites. KSU has recently built $7 million new facility for Bioprocessing Industrial Value Added Program (BIVAP) housed in the Department of Grain Science and Industry, containing three major labs: Bio-Materials & Technology Lab (BMTL); Extrusion Technology Lab; and Fermentation Technology Lab).

Wichita State and the NIAR faculty are experts in aerospace materials characterization; and the Pittsburg State University researchers have experience in polyurethanes and specialty polymers which play a critical role in many medical products. Connection of this intellectual capital throughout the state has high potential to link industrial, medical and aerospace applications requirements to develop novel biologically-inspired materials and products for diverse applications. Future collaborations will extend across state lines, particularly into Missouri and Oklahoma. Training of students in these important fields while simultaneously supporting development of industries in which they can be employed will help keep our best and brightest in our state as well as attracting more companies and skilled workers from other regions.(1)

V. Describe the implementation strategy including the implementation champion(s) and the organizational "home" for implementation

We propose that KCBIMT will be the organizational home and driving force in forging collaborations between the existing agricultural, engineering, materials science and medical communities, industry and government. Medical devices can be developed for both animals and humans, therefore involvement of medical doctors, physical therapists, dentists, and veterinarians is needed. Materials exploiting agricultural commodities require involvement of materials experts, chemists, engineers and geneticists. Similar to the Kansas NSF EPSCoR model, KCBIMT can have a movable home that is connected to the current Center Director, most likely at either KSU or KU since proximity to both the agricultural and the medical and/or veterinary communities is paramount. Branches will be located at each collaborating institution.

It is recognized that the proposed merger may well result in multiple Federally funded Centers of Excellence in materials, separated along the lines of biomaterials and bioproducts (industrial applications for plant based materials) and biologically-inspired materials and devices (those mimicking the response of living systems primarily targeted at the medical community and aerospace communities). Nonetheless, the similarities required in interdisciplinary interaction with the same Kansas expertise and the potential synergies in ensuring open communication among diverse materials researchers and industries justifies our combined KCBIMT catalyst proposal.

The specialized "Technology Opportunity Recognition" Forums can be held at various regions throughout the state to better facilitate communication and state-wide collaborations. In order for these efforts to succeed, there will need to be a Champion of the effort on each university campus or industry and at least one Champion who directs the Center. An Administration Director is also required; this person must be knowledgeable and experienced in both the technology and business aspects of materials development and bioproduct or biologically-inspired product development. A Board of Directors and an Advisory Council will be formed to help guide the directions of KCBIMT.

The first step envisioned in this process is to facilitate specialized "Technology Opportunity Recognition" Forums in which all interested individuals are invited to learn more about specific hot areas of potential growth in biologically-inspired materials and technologies for industrial, textile, pharmaceutical, biomedical and/or aerospace materials or devices. Forums should include regional, national and international opportunities in that field. Grant and loan programs are envisioned for a variety of industry and academic research and development efforts that will prove their value based on potential future development into a successful consumer product. Educating both companies and academia about the opportunities available in federal SBIR programs is one goal in these funding efforts.

VI. Describe the resource requirements:

Leadership: The Center must be led by a dynamic, capable, dedicated and sustained individual who is familiar with the technical field as well as experienced in biobased materials and bioproduct or biologically-inspired devices fields. Preferably, this individual will have a commercial background, technical expertise, and an international reputation. Recruitment of such a person will be the responsibility of the Board of Directors, which will include representatives from areas such as academia, industry, government institutions with expertise in biologically-inspired materials, biobased materials and bioproducts, medical devices, management, and finance. The human and intellectual capital for local leadership within academia, industry and government agencies identified in section IV exist and are in-place within the State of Kansas.

Infrastructure: The infrastructure for biologically-inspired materials and technology should be located within reasonable driving distance of the University of Kansas Medical Center (Kansas City) and the Kansas State University School of Veterinary Medicine to facilitate communication with medical personnel. An additional regional, though not Kansas, medical resource is the University of Missouri Kansas City School of Dentistry. The infrastructure for biobased materials and bioproducts should be located within the driving distances of Kansas State University (KSU) (Manhattan) to facilitate communications with biobased materials and bioproducts personnel. Many of the physical facilities requirements to ***start*** the KCBIMT initiative are in-place at the institutional offices of the University campuses (KSU, KU, PSU, WSU), but some growth in research infrastructure (equipment, space, personnel) is to be expected to sustain and grow the initiative. There will also be a need for a virtual infrastructure to readily enable statewide communication among the satellite campuses.

Capital: The Hot Team has considered both a minimum and an ideal level of funding to ensure the success of the proposed initiatives. Our first priority is establishing a central coordinating body tasked with identifying research opportunities, coordinating proposals, ensuring competitive distribution of resources, identifying teaming opportunities and running proposed technology forums. Increasing access to capital for new research infrastructure (equipment, personnel, operation) and research seed funding for new company startups and to encourage industry-academia-government research teaming will accelerate the success of the initiative. Public capital will be in the form of recurring federal and state funding for federal centers of excellence in Bio-Materials by Design and Biologically-inspired Materials and Devices, likely to result from the proposed initiative. Investor capital will be in the form of industrial and commercial joint development agreements funding research with commercialization possibilities. Entrepreneurs and angel investors will be attracted to the exciting new ideas developing in the national center.

Minimal support to start the initiative is believed to be approximately $1.3M per year (direct). Details supporting this estimate may be found in Appendix C. A minimum of five years support must be established to ensure the long-term success of the initiative. These funds could come from government funding such as NSF, or as an appropriation from the Kansas Biosciences Authority. Note that attempts are already underway to supplement any Kansas Biosciences Authority funds to support the KCBIMT formation and increase its rate of growth (see Appendices A1 and A2). We anticipate that many more funding initiatives (Center-based and general collaborative research proposals) will be proposed as KCBIMT enables more interactions of industry and researchers across the state. A more significant investment (approximately $5.3M per year) will enable rapid growth, by enabling rapid expansion of infrastructure (personnel, equipment, operation) to support the growing industry base.

Regional communications and domestic/global branding-marketing: Regional communication will be provided through the Technology Opportunity Recognitions forums where students, faculty, representatives from research and business industry will meet and exchange ideas as well as establish and strengthen collaborations. Enabling the bridging mechanism between strong Kansas industries and research foci will enable unilateral marketing of Kansas' current expertise in advanced materials and our growing expertise in bioproducts and biologically-inspired devices. Initial industrial partners are identified in Appendix D.

VII. Describe how the initiative will be sustained (through an existing mechanism, new mechanism, collaborative partnership, federal center of excellence, etc.)

The Hot Team has submitted two pre-proposals for initial planning and development of the proposed new Center through the KS NSF EPSCoR Major Initiatives to Improve Research Infrastructure request for proposals. If awarded, these planning grants would jump-start the efforts tremendously. The new Center would then apply for funding of an NSF Center grant, perhaps in the Materials Research Science and Engineering (MRSEC) program as well as the Science and Technology (S&T) and NSF Engineering Research Center programs. Partners on these programs would include collaborators at KU, KSU, PSU and WSU (including the FAA Center of Excellence at the NIAR at WSU), as well as local industry and government. Research collaborations would extend across state lines, as significant collaboration efforts with the University of Missouri Kansas City, Oklahoma State University and the University of Delaware are already in place. Development of biologically-inspired materials and technology for use in foreign countries is an area in which significant target markets might be achieved. The Center would extend current collaborations in each university to include partners in these opportunity regions.

On the business side, a Consortium between and among the state's universities and agencies will be formed which will financially support research for continuous improvement in the economic competitiveness of the newly developed biobased materials and products and biologically-inspired materials and devices. The biomaterials and advanced materials research programs at KSU, KU, PSU and WSU currently are successful at securing external funds from federal and industrial sources. This Initiative will add momentum to current successes and expand this funding base.

Industry leadership and partnerships are critical to the success of a statewide Initiative. Existing Kansas companies working in bioproducts (which will be indexed by Commerce) will help ensure product commercialization makes sense and existing companies are part of the future. Kansas has existing capabilities in this arena that need to be harnessed and learned from. Additional corporate partners are identified in Appendix D.

A Kansas-based Initiative will need to be sustained through an integrated combination of in-state "start-up" funds and human capital at the state universities, state government, as well as involvement of the private sector. In addition, an effort such as this will need the aggressive pursuit of multiple collaborations with many other persons, organizations, and entities in both the public and private sectors.

VIII. Describe 6–8 specific performance metrics that the initiative will influence and impact and how:

1. Increase by at least 30% during the next 2 years, the number of SBIR and STTR proposals awarded in Kansas. Collaborative efforts among Kansas industries and academia will be specifically targeted; however, outside collaborations will also be encouraged since this will facilitate the flow of federal funds into Kansas.

2. Increase leveraged public, private and direct foreign investment in Bio-materials and products, Biologically-Inspired Material Systems, and Biologically-inspired systems and devices.

3. Create five new companies and assist in the expansion of five existing companies in the Biologically-Inspired Material and technology fields over the next 5 years, thus generating new high tech jobs, retaining engineering, scientific marketing and financial talent, and bringing additional revenue to Kansas. This initiative will result in the short-term realization of new jobs for engineers and scientists. Many of these jobs would be located in or near the agricultural production regions of the state. Subsequent growth would result in additional jobs in engineering, science, research and development, manufacturing, and marketing. Metrics will include, for example, new company start-ups from university spinouts, corporate spinouts, entrepreneurial foundings and the number of new companies or manufacturing facilities established in Kansas from successful commercialization of University technology and/or entrepreneurial efforts.

4. Conduct a continuing series of "Technology Opportunity Recognition" Forums around the state that will bring representatives from both academia and industry in order to share knowledge and initiate collaborations among institutions within and outside of the state in the areas of advanced materials and medical devices. A minimum of four such forums should be conducted each year.

5. Increase 'brain gain' of scientists, managers, business leaders, entrepreneurs, faculty and students. Identify the increase in scientists engaged in research in Biologically-Inspired Materials and technology, "knowledge workers" employed, and faculty/students connected with similar research and development programs across the state. The new jobs that will result from this initiative will be primarily in the area of engineers, scientists, entrepreneurs, and faculty and students in these disciplines. A significant portion of these jobs would be located in the agricultural production regions of the state. Nearly all of these jobs have salaries well above the current state average. There are also needs for commercialization staff to close the circle.

6. Educate students and faculty on the commercialization process by conducting modular training courses and building on collaborative examples of class projects as prototypes for future bioscience industry activities in Kansas.

7. Increase knowledge sharing between academia and industry by college internships at entrepreneurial startups and other center members; knowledge sharing will cement relationships and allow Kansas to retain some of the best and brightest talent. Supplemental funds for such initiatives are available from many government agencies such as NSF, USDA, DOE, DoD and others.

8. Enhancement of university-industry relationships through increased contract research dollars, endowed chairs and royalty and licensing fees. Measurement of growing university-industry relationships will be through increases in these parameters. This initiative will only be successful with the full support of the state's universities and their close partnership with industry. During the later phases of this program, it is anticipated that most of the research support generated will be from industrial sponsors. These industrial contributions will leverage the initial research support provided by the Kansas Biosciences Authority.

9. Increase internships for high school and college students, and experiential learning opportunities for students in higher education. Become a State Center for Technology-Based Entrepreneurship. Quantify the number of internships granted to high school and college students by companies engaged in Biologically-Inspired Material Systems, Bioproducts and Biologically-inspired Devices industries.

10. Encourage awareness and utilization of products and technologies developed in Kansas through KansasBio website and possibly small incentives for members of KansasBio.

11. Promote "bioincubators" that house the entrepreneurial startups and provide shared research space and infrastructure. Partnerships with existing institutions, such as BIVAP and NISTAC in Manhattan, KS that already have the infrastructure needed to nurture new companies will expedite this process. Funding for such endeavors can be obtained from the Kansas Biosciences Authority, or federal funding.

12. Seek partnerships with venture capital groups and industry leaders, possibly through an advisory council, that can investigate the scientific and commercial prospects of the entrepreneurial technologies and provide limited seed grant funds, using the Biosciences Authority funding to start new companies and pursue more comprehensive product development. Perhaps companies that are existing stakeholders in Kansas could serve as the "angel" investors, i.e. Boeing, Koch Industries, Bayer, Georgia-Pacific and others.

References:

1. Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2004-05 Edition, Biomedical Engineers, on the Internet at http://www.bls.gov/oco/ocos262.htm (visited March 11, 2005).

Some Websites of interest:

- http://www.knovel.com/knove
- http://www.bioproducts-bioenergy.gov/default.asp
- http://www.asminternational.org/images2/mpmd.pdf
- http://www.asminternational.org/Content/NavigationMenu/Magazines/Materials_and_Processes_for_Medical_Devices/MPMD.htm
- http://eship.engr.ku.edu/
- http://www.bls.gov/oco/ocos262.htm
- http://www.ncaur.usda.gov/HotTopics/increasedfunding/biobased.htm

IX. Appendices

Appendix A1. 2005 NSF EPSCoR Major Initiatives to boost Biobased Materials and Bioproducts, Letter of Intent submitted in March 2005

Appendix A2. 2005 NSF EPSCoR Major Initiatives to Improve Research Infrastructure *Center for Biologically-Inspired Material Systems*, Letter of Intent submitted in March 2005

Appendix B1. Examples of Current Collaborative Research Projects Underway in Development of Agricultural-Based Biomaterials and Bioproducts

Appendix B2. Examples of Current Collaborative Research Projects Underway in Development of Biologically-Inspired Material Systems

Appendix C. Bracketed Estimates of Capital Resources Required to Initiate and Sustain KCBIMT

Appendix D. Action Plans for KCBIMT Corporate/Industry Movers and Influencers

Appendix E. Relationship to Senator Pat Roberts' Material Science Advisory Committee on Science, Technology and the Future

Appendix F. Relationship to Senator Pat Roberts' Aviation Task Force on Science, Technology and the Future

Appendix A1

2005 NSF EPSCoR Major Initiatives to boost Biobased Materials and Bioproducts, Letter of Intent submitted in March 2005

NSF Center Proposal: Strategic & Interdisciplinary Initiative: Bio-Materials By Design (SII-BMD)

Letter of Intent submitted March 2005

Executive Summary

The Strategic & Interdisciplinary Initiative: Bio-Materials By Design (SII-BMD) applies an **Interdisciplinary Strategic Approach** to target the design of bio-materials using molecular principles for specific applications that are currently fulfilled by coal, oils and gas. The **Vision** of the SII-BMD aims to foster a nationally and internationally recognized center of excellence funded by National Science Foundation or KS Bioscience Initiative Program in the next 5 years. The focuses of SII-BMD are to facilitate discovery, reaction pathways, mechanism, modification, theory, and characterization of bio-materials and bionanotechnologies; to develop new technologies of processing and utilization of agriculture commodities and by-products for value added consumer's products; to develop integrated life cycle analysis tools and commercialize newly developed technologies; to produce trained students and educate K-12 youth in this cutting edge field to meet future needs of both academia and industry; to begin to generate fundamental knowledge and develop novel technologies for both research community and industry in the biobased material field; and to establish a platform and strengthen infrastructure with strong interdisciplinary focused research groups in bio-materials area.

Bio-molecules and their monomers are building blocks for bio-materials that have shown tremendous potential for many current applications, such, adhesives, resins, composites, chemicals, coatings, and solvents. However, limitations exist due to their reduced performance and durability. The research scope of this initiative employs a highly integrated approach to address problems of fundamental and technological interest. The proposed SII-BMD intends to establish a strong foundation for bio-materials R&D both locally and worldwide. The **Research Target** of the SII-BMD is to achieve comprehensive understanding, information, and knowledge of bio-molecules so as to design novel bio-materials with desirable functional properties for industrial, pharmaceutical, military, and textile applications; and to develop novel technologies of bio-materials processing and manufacturing; and to develop tools of life cycle analysis with

integration of ecological balance, resource depletion, human health, economic sustainability, and social impacts. The **Target of Education and Outreach** of the SII-BMD will focus on providing Research Experiences for Undergraduate students (REU), developing interests in bioscience through SII-BMD programs for K-12 youth, training graduate students and postdoc research associates as well as young faculty members in this cutting edge field.

Kansas State University (KSU) will be the leading university of the SII-BMD program focusing on the core R&D and commercialization targets. K-State also will conduct the main education program including the REU, K-12 outreach activities. WSU and KU are major subcontractors: WSU focuses on developing new tools of life cycle analysis (LCA) of bio-materials from raw materials to products to re-use to recycle to disposable. KU will focus on pharmaceutical and medical products derived from biobased materials.

The interdisciplinary team of bio-materials at K-State has been recently recognized as one of the two Targeted Excellence Programs by K-State Provost Office with $900,000 award as seed funding from 2004 to 2007. The SII-BMD, if selected, will be supervised under the K-State Vice Provost Office for Research, by Dr. James Guikema, Associate Vice Provost for Research, under the umbrella of Bioprocessing Technology Council that is being formed at K-State.

3.0 Team Members, Name and Contact Information

PI:

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Co-PIs: 12 faculty from KSU, WSU, KU,

Industries and National labs collaborators (USDA, US Army, DOD national labs, 4 industrial partners: 2 large resin companies and 2 Kansas start-up companies)

Team is Still Open for other participates from all KSU, KU, WSU, PSU, Industrial partners in and out of KS

Appendix A2

2005 NSF EPSCoR Major Initiatives to Improve Research Infrastructure *Center for Biologically-Inspired Material Systems,* Letter of Intent submitted in March 2005

Kansas Center for Biologically-Inspired Material Systems (KCBIMS)

KCBIMS comprises a statewide research infrastructure aligning existing strengths of Aerospace Engineering and materials science with emerging strengths in Biosciences and biomedical product development. Historically, most advances in biomaterials and medical technology were originally developed in the aerospace and defense fields, then translated for specific uses in medical products. A current area of high potential in both traditional materials and biomaterials is development of "smart materials", many of which are biologically-inspired, and biomimetic material systems.

The proposed Center will establish bridges between advanced materials and biomaterials researchers throughout the state and region, across aerospace, bioscience, materials science and medical industries. This critical bridging mechanism is of importance to the KEGA initiative. We plan that KCBIMS' Administrative Director will operate through KTEC. The first step will be to facilitate specialized "Technology Opportunity Recognition" forums for all concerned to learn about potential growth areas in advanced biomedical and/or aerospace materials or devices. These forums will identify areas for research investment and growth by bringing together industry, academia and potential entrepreneurs to form collaborations crossing traditional disciplines to enable enhanced research infrastructure and economic development in Kansas.

The KU-PI will be KCBIMS' overall Director; co-PI-teams at each participating university campus or private industry will direct specific activities on-site and promote inter-institutional collaborations in targeted research areas. While the general research focus will be development of biologically-inspired and biomimetic materials, the specific focus areas may change over time. Decisions on KCBIMS focus areas will be made by the PI, Associate Directors, and the Administrative Director based on Technology Opportunity Forum outcomes, and advice from KCBIMS' Advisory Board. Two or three research grant programs are envisioned for collaborative industry and academic research projects. The first focus area is envisioned to be research in light-weight biologically-inspired materials.

Educational goals of KCBIMS will be to help Kansas engineers and scientists learn about special materials and design requirements in the biomedical field, promote entrepreneurship education inside and outside of universities, and show companies and academia opportunities available in collaborative federal research, including SBIR and STTR programs. KU-Lawrence has strong and growing programs in Bioengineering, Biophysics, and Technology Entrepreneurship, having ten biomedical engineering faculty and two new open positions (searches in progress). One position is for a nationally recognized director, who will facilitate development of additional positions and lab space on the KU-Lawrence and KUMC campuses. The Co-PIs at KSU and NanoScale Materials, Inc. have expertise in nanomaterials and composites, WSU Co-PIs are experts in aerospace materials characterization, and the PSU Co-PI has expertise in polyurethanes, a common material in medical products. Connection of these

campuses has high potential to link medical and aerospace applications to develop novel biologically-inspired systems for use in biomedical applications. Future research collaborations will extend into Missouri and Oklahoma, as significant collaborative efforts with UMKC and OSU are already in place (having resulted in a 2004 NSF MRSEC preproposal submission). KU is also building connections with universities in Asia; KCBIMS would extend current collaborations to include national and international partners.

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Please note: *Not all people listed will be funded through the NSF EPSCoR Research Infrastructure proposal mechanism. The investigators listed below comprise the core teams for building the research infrastructure that will be required to initially build and grow the KCBIMS. We anticipate that the Technology Opportunity Recognition forums and two or three research collaboration projects could be funded initially.*

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Appendix B1

Examples of Current Collaborative Research Projects Underway in Development of Agriculture-Related Biomaterials and Bioproducts

Kansas State University and Pittsburg State University currently have several programs targeted at utilizing crop components for industrial applications. These programs include materials experts, chemists, engineers and geneticists. One of the largest of these programs is headed by Dr. Xiuzhi Susan Sun. The targets of this program's five year plan, funded in part by KSU, USDA and numerous government and industry grants is focused on the following objectives:

1. Commercialize biobased adhesive technology for foundry industry – current research contract with a large international industry for commercial feasibility testing.
2. Commercialize biobased adhesive technology for childrens glue and color paints - this shows great potential with needed BMTL-BIVAP and AMI and AgRenew scale up.
3. Commercialize biobased adhesive technology for wood veneer and particle boards – large resin industry partnership is in place, and currently efforts on pilot scale processing facility to assist commercial feasibility testing,
4. 4.Develop biobased adhesive technology for low density fiber packaging board – collaboration with DOD Navy and US Army national lab.
5. Examine biobased adhesives potential for packaging and labeling – glass bottles, plastics, laminations, food packagings, etc. can be new technology down the road very soon for BMTL-BIVAP and AMI to commercialize.
6. Fatty acids platform to design adhesive and resin utilizing plant oils.
7. Edible binders developed for animal feed industries – two ongoing contracts with industries.
8. Utilization of DDGS by-products from ethanol production for adhesive and binders.

Significant areas of **intellectual property** will develop from this research on material development including:

1. tailored development of novel biobased adhesives and resins with desirable properties;
2. knowledge of chemical and physical properties of biobased materials to be later used for industrial uses;
3. new technologies and new uses for materials produced in excess by American agriculture; and
4. leveraging the efforts of new Grain Science Complex and the new $7 million facility to attract industrial collaborations and cooperations.

Advanced Manufacturing Institute (AMI), a current KTEC center of excellence, combined with new BMTL-BIVAP facility and industry partners will provide basis for strategic commercialization and technology transformation programs with new technologies. This action plan also has impact to KS Bioscience Initiative and K-State Targeted Excellence Biomaterials By Design Program.

K-State research programs are established in biobased adhesives, carbohydrate based plastics, straw composites, fatty acid based carbon processing, and textile applications, incorporating faculty from three colleges and six departments.

K-State commercialization programs are integrated with the Ag Innovation Center and the College of Business to assist development of new businesses.

The market for biobased industrial materials is large. According to information supplied by Dr. Sun, about 20 billion lb adhesives and resins are used annually in the U.S., and most of them are produced from petroleum-based and synthetic chemicals. For example, among those, about 8 billion lb are formaldehyde based adhesives. Formaldehyde emission has been an environmental issue for some states and countries. Recent California regulation requires that resins sold to California should contain no formaldehyde component. Several chemicals have been recommended as alternatives to formaldehyde based resins, but none of them has passed the regulation. There is an urgent need to produce adhesives and other chemical based plastics, coatings, and building materials from biobased materials instead of the petroleum-derived materials from which most of these products are now made. Substituting for biobased materials grown in the U.S. will reduce our reliance on imported oil.

The United State has huge surplus protein abased materials from soy meals, and corn or sorghum glutens from oil, starch, ethanol and bio diesel production processes. This will increase in the next 20 years as biofuel production increases. Several technologies for making and using adhesives from soy proteins have been developed in K-State labs in recent years (1-17). However, large efforts in R&D are still needed to develop processing methods at pilot scale and commercial scales.

Pittsburg State University has a parallel program focused on finding uses of crop derived oils for similar applications. KSU also has several programs in various departments focused on BioFermentation for ethanol and for biobased biochemicals that can be used as polymer building blocks.

The Kansas Polymer Research Center (KPRC) at Pittburg State University is the best equipped polymer research lab in the Midwest. The KPRC has a range of patents and references in the field, along with one of the world's strongest agri-business companies, Cargill, Incorporated as a commercialization partner. The Kansas Technology Center is co-located on the campus, with one of the four accredited undergraduate plastics programs in the nation. The KPRC also has excellent connections with leading polymer institutions in the world and strong support from the City of Pittsburg.

K-State, in cooperation with Pittsburgh State University, offers a Graduate Certificate Program in Biomaterials Science and Engineering which requires an internship for completion. This program will provide a pool of interested and motivated students who can be available to serve the growing bioprocessing industry in Kansas.

Kansas State University also has a significant research, teaching and degree programs in various grain and crop processing technologies including milling, extrusion, fermentation and chemical modification. Currently, crops are now developed primarily for food or feed applications. Processes such as milling, extrusion, extraction and fermentation are designed to extract starch, protein, and lipids for bulk applications in food and feed processes. With the exception of baking performance in wheat, little is being done to improve crops for specific processes such as extrusion, fermentation, extraction etc….

Even with this growing interest and significant investment in resources, little has been done to date in Kansas to actually begin a breeding and crop improvement program to maximize the concentration and reactivity of key biomaterial precursors produced by the crops under research. It is clear, however, that there is considerable potential for improvement of crops for valuable biomaterial precursors. A preliminary study by Bill Schapaugh and Susan Sun indicated there is genetic variation in cultivated soybeans for adhesive properties. This indicates soybean cultivars could be developed that made better adhesives. A number of other programs have identified genetic variants in crops currently grown in Kansas, like soybean (Graef et al. 1985 J Am Oil Chem Soc 62:773-), sunflower (Soldatov 1976, Proc Int Sunflower Assoc) and Rapeseed (Auld et al. 1992, Crop Sci 32:657-) that increase the proportion of valuable oils, like oleic acid (18:1). Genetic engineering experiments with experimental plants have

demonstrated the potential for producing rarer oils with longer chains or different patterns of saturation (Qi et al 2004 Nat Biotech 22:739).

A focused effort to identify the best and most valuable protein, lipid, starch and fiber sources for industrial applications and breed for maximum expression of those compounds could result in developing crops with significant value added traits for the non-food industrial sectors.

Appendix B2

Examples of Current Collaborative Research Projects Underway in Development of Biologically-Inspired Material Systems and Devices

Example 1. Light-weight Piezoelectric Metal Foam Scaffold for Attachment of Hard Tissue and Dental Implants and/or Structural Embedded Sensors – *Collaboration between researchers at KU Mechanical Engineering, Oklahoma State University Chemical Engineering, UMKC School of Dentistry. Initial work currently funded by Honeywell KCP.*

Light-weight piezoelectric materials have application in various industries in transportation and defense. A technique has been developed to create lightweight porous structures with the unique structural properties of the reentrant structure by embedding piezoelectric particles in the metal matrix of the struts. The reentrant structure has unique characteristics, including a negative Poisson's ratio, that can be tailored. As a result of the negative Poisson's ratio, the reentrant structure has been shown to exhibit interesting relationships between apparent elastic and shear moduli. It also has a nonlinear load-deformation response that can be controlled by method of preparation. The Poisson's ratio and nonlinear load-deformation response can be isotropic or anisotropic in overall structural presentation. The reentrant structure has unique vibration damping characteristics and indentation behavior in comparison to most other materials. Some of these attributes, combined with the ability to generate electrical signals, make this novel material interesting for use in various applications involving control, actuation or stimulation in aerospace and biomedical implants.

Reentrant structures with piezoelectric characteristics can be created by using a CP Titanium strut matrix incorporated with randomly dispersed nanoparticles of Barium Titanate ($BaTiO_3$ - the piezoelectric material). The metal matrix–piezoceramic inclusion structural materials will be manufactured by extrusion based robotic deposition with direct write technology utilizing highly concentrated colloidal suspensions as feedstock; a technique developed by one of the co-investigators. Consolidation of the metal and ceramic particles requires heating above the Curie temperature of the piezoceramic. Studies indicate that repolarization of the BaTiO3 to induce aligned piezoelectric response can be done with the particles embedded in the metal matrix. Traditional and reentrant open-celled structural materials will be created with a Ti matrix at least two different loadings of BaTiO3 particles. Quasistatic and dynamic characterization of these materials are being performed. FEA models of the reentrant structure are being developed in collaboration with Honeywell KCP. These models will be used to predict the effect of piezoelectric ceramic loading on electrical and mechanical responses. A specific application for which this information will be very important is use of this material as porous scaffolding for attachment of implants. It is hypothesized that unique scaffolds (in terms of pore size, rigidity, and electrical behavior) could be made that will promote controlled formation of various types of soft tissue or hard tissue. If this hypothesis is correct, reentrant structure scaffolding could be to promote multiple types of tissue generation within one implant for graded tissue repair. In these applications, it is important to understand the electrical responses and strains that the cells and associated materials experience within the metal scaffolding. Such understanding requires the integrated efforts, tools and knowledge of biologists and the engineers working within KCBIMS.

Example 2. Insect Cuticle as a Motif for Light-weight, High-Strength Composite Materials *Collaboration between researchers at KU Chemical Engineering and KSU Chemistry. Work currently funded by NSF.*

Insect cuticle (loosely speaking, insect shells) is a very high strength material, with moduli that can exceed 100 GPa, rivaling that of metal alloys and the best aramid and carbon-fiber composites. Cuticle is a composite of crystalline chitin microfibrils embedded in a protein matrix. The cuticle of crustaceans can

add up to 40% calcium salts, thus making a ceramic-like composite material. The origin of the high performance properties of this material are clearly related to the hierarchical structure of the cuticle. The chitin fibers have a very high surface area per unit volume, being on the order of 3 nm in diameter (as opposed to synthetic fibrous composites where the fibers may be micron scale or greater). The protein matrix includes crosslinking agents and plasticizers. Initial studies indicate that the extraordinary stiffness of this material may be due to the silk-like composition combined with highly crosslinked structure, in which chitin fibers are embedded.

Although the valuable material properties of insect cuticle have been recognized for several decades, it is still poorly understood as a composite material. For example, it is not even known if the chitin is crosslinked to the protein matrix or not. The team of investigators has current funding from NSF to study this question using these cloned insect cuticle proteins. The information acquired from this basic science study will be applied to the efforts of KCBIMS to develop new hierarchical bio-inspired materials. A recent study by Gong and Osada demonstrated that the moduli of an interpenetrating network of a stiff gel and an elastic gel can be well over an order of magnitude greater than the moduli of even the stiff network. This work has been replicated in the KU laboratory; modulus values on the order of that reported for articular cartilage in a highly hydrated gel have been achieved. This behavior may elucidate function of chitin-protein composites that comprise insect cuticle.

In future work, we will use both the native insect cuticle protein and silk-like polymers from Protein Polymer Technologies and crosslink it in the presence of chitosan (a soluble derivative of chitin) to develop both hydrated, high strength materials of potential use in biomedical applications like tissue engineering scaffolds, and as hydrophobic, dry materials for use in non-medical applications where high strength combined with light weight and biodegradability are desired. Another fiber component that can be used is bacterial cellulose, which is a highly anisotropic nanofiber which can be produced by bacterial fermentation. This material has medical applications in absorbent pads and high strength applications as in audio speaker cones. Using the insect cuticle motif, a composite of bacterial cellulose and insect protein may generate a very high performance material. Developing techniques to align and organize such fibers in a matrix would further mimic the hierarchical structures present in insect cuticle.

Example 3. Kansas Industry Development of Medical Products Invented in Academic Settings: Pinnacle Technology

Pinnacle Technology's glutamate biosensor and wireless data acquisition system is based on implantable biosensor technology invented at The University of Kansas by Higuchi Distinguished Professor of Chemistry and Associate Vice Provost for Research, George Wilson (Patent number 5,165,40). Pinnacle worked on several NIH SBIR grants with Dr. Wilson to develop the sensors into a marketable product. The glutamate biosensor is an enzyme-based sensor designed for in vivo use with rats, but it is valuable for a variety of applications including in vitro, in situ and cell culture measurements. When used in combination with Pinnacle's 3102RH potentiostat (providing wireless, real-time in vivo data acquisition) the versatile glutamate biosensor is an extremely powerful measurement tool for researchers.

The system includes a head mounted sensor, data acquisition and telemetry system. The sensor measures glutamate, a key neurotransmitter in the brain. It plays a vital role in Parkinson's, Alzheimer's, Huntington's, heart disease, depression, etc.

The primary advantage of this technology is the ability to conduct behavioral experiments along with real-time neurophysiology for drug response. The current standard for measurements of this type is microdialysis. Microdialysis requires a tether and provides approximately 1 sample every 2 to 5 minutes. In comparison, the "rat-hat" sensor and electronics are wireless, provide a sample once per second, and have a true temporal resolution of 4 seconds. Pinnacle launched the product at the 2004 Neuroscience Conference and is receiving increased interest in the product. Sales have been brisk, and two international distributors have adopted the system. For information, go to www.pinnaclet.com.

Pinnacle is also collaborating with Northwestern University to develop a turn-key EEG/EMG system for mice. This system is currently undergoing beta testing at several laboratories. To date the response has been overwhelmingly positive.

Both of these examples show the benefit of university/industry collaboration and the pursuit of federal dollars to offset R&D costs. The proposed center would facilitate this type of collaboration on a broad scale, bringing grant dollars to the state while growing our existing companies and facilitating start-ups.

Example 4. Kansas Industry Development of Advanced Materials with Intellectual Property Transferred from an Academic Setting: NanoScale

Based in Manhattan, Kansas, NanoScale (www.nanoactive.com) is a dynamic, innovative technology Company founded in 1995 to develop and commercialize its proprietary NanoActive™ materials (NanoScale's branded metal oxides) and technologies. The technology originates from research conducted by Prof. Kenneth J. Klabunde at Kansas State University. Nanotechnologies are beginning to bring profits to many consumer product makers by providing either novel products or important improvements to existing products. For example, nanotechnology has produced self-cleaning windows, stain- and wrinkle-resistant clothing, glare-reducing and fog-resistant coatings for eyeglasses and windshields; it has also dramatically increased computer memory, produced better sports equipment, improved cosmetics and sunscreens, and had resulted in lighter and stronger auto components.

The expertise of NanoScale lies in the area of developing highly reactive nanomaterials, tailoring nanomaterials to achieve specific properties to meet Customer needs, product characterization (including Analytical Testing Program for third parties) as well as economically scaling up production of such materials. NanoScale business segments are:

- Sales of its NanoActive, NanoActive-G and NanoActive-S materials, sales of developmental materials and sales of FAST-ACT.
- Government contracts
- Joint Development Agreements
- Analytical Services

NanoActive materials are based on benign (human health and environmental) metal oxides such as magnesium, calcium, zinc, aluminum and titanium oxides. Extensive toxicology testing has revealed that these materials are non-toxic. In addition to the off-the-shelf materials, NanoScale provides developmental materials including other types of metal oxides, mixed metal oxides, coated materials and nano metals. There are several unique properties of NanoActive materials that make them particularly attractive for a variety of applications:

- Very high specific surface areas (20 to 700 m^2/g)
- Large porosities (up to 1 cc/g)
- Unusually small crystallite sizes (typically 2-10 nm)
- Unique morphology (many highly reactive corner and edge sites)
- Enhanced chemical reactivity (high binding affinity and adsorbing capacities as well as increased kinetics)
- Availability in granulated or stable suspension forms (granulated forms retain surface areas, porosities, and sorbent capacity; whereas suspension forms are available in various aqueous and non-aqueous solvents.
- Dispersability as a clear liquid or film or spray; and
- Availability in production quantities (off-the-shelf products).

NanoActive materials have shown utility in a variety of applications, including: (1) Odor control; (2) Antimicrobial technologies; (3) Decontamination by destructive adsorption, (4) Air and water purification, (5) Acid gas scavenging and (6) Protective skin creams and clothing.

NanoScale's proprietary synthesis methods were developed with a goal of enhancing adsorption kinetics and chemical reactivity for the purpose of detoxification of multiple toxic chemicals including air pollutants, hazardous chemicals and chemical warfare agents. This technology led to the development of FAST-ACT®, a chemical hazard containment and neutralization system that consists of a proprietary mixture of NanoActive materials. FAST-ACT was developed in conjunction with the United States military and originally targeted the destruction of chemical warfare agents. NanoScale then expanded the product's utility to contain and neutralize a wide range of toxic chemicals in addition to the destruction of warfare agents.

NanoScale is headquartered in a new state-of-the-art 20,000-ft^2 laboratory and office facility in Manhattan, Kansas. This facility includes chemical laboratories, a microbiological laboratory, quality control/analytical laboratory, administrative offices and manufacturing plant. NanoScale possesses extensive scientific equipment and instrumentation that are needed for R&D. Additionally, NanoScale has a very strong collaboration in place to use instrumentation at Kansas State University (both facilities are located within 1 mile of each other in Manhattan).

NanoScale's patent portfolio is a key asset and is an active component of its overall business strategy. NanoScale's proven ability to identify, develop and successfully market patented products provides a degree of competitive insulation in the marketplace.

Appendix C

Bracketed Estimates of Capital Resources Required to Initiate and Sustain KCBIMT

Table 1. Estimated yearly capital resources required to initiate and sustain KCBIMT at both a minimum and ideal level for the first five first years. Subsequent funding levels would be similar, but should grow or be supplemented by external federal funding.

Full time Administrative Director, 12 mos (ideal)	114,000	114,000
Full time administrative assistant, 12 mos	36,000	36,000
Local Center Director Stipend	10,000	40,000
Fringe	44,800	53,200
Recruitment of Administrative Director	10,000	10,000
Materials and Supplies	10,000	25,000
General Fund for Institution Expenses	8,000	8,000
Travel	15,000	15,000
Technology Opportunity Recognition Forum Expenses	12,000	12,000
Communication	2,000	2,000
Computer & networking	10,000	10,000
Subawards/Seed Funds:	1,000,000	3,000,000
Competitive Equipment Award Funds:	0	1,000,000
Competitive Personnel Award Fund	0	1,000,000
DIRECT COSTS:	**$ 1,271,800**	**$ 5,325,200**
INDIRECT and DIRECT COSTS:	$ 1,844,110	$ 7,721,540
(if overhead is provided)		

Appendix D. Action Plans for KCBIMT Corporate/Industry Movers and Influencers

Enlisting these companies as stakeholders in the Kansas Center for Biologically-Inspired Material and Technology and underwriters of the Technology Opportunity Recognition Forums will ensure the initial viability of the Center and lend credibility to the Kansas concept in the early stages of development. These "alpha" supporters have the power to attract sister and "satellite" companies that serve them with a variety of components, related products and services to also participate in the Center. These early adopters may also be good sources for individuals to serve on the Center's Board of Directors and Scientific Advisory Council.

Immediately following the formation of the Center it will be necessary for the Director and Board Members to become involved in existing Advanced Materials and Medical Device Trade Associations, such as the Association for the Advancement of Medical Instrumentation, Advanced Materials Research Institute, Medical Device Forum and the Medical Device Manufacturers Association. They will also attend industry meetings and shows such as the Biotechnology Industry Organization (BIO), June 19-22, 2005 in Philadelphia and make personal contact with the upper management and business development executives of the "alpha" companies to discuss material/device development, collaborative opportunities, supplier requirements, participation/support of the Kansas Center.

Company	Location	Kansas Connection
Cargill		Current primary industry partner for Kansas bioproducts
Medtronic	Minneapolis, MN	Patents produced in Kansas currently in use
Boston Scientific	Natick, MA	
Guidant	Indianapolis	
Zimmer Holdings	Warsaw, IN	
Baxter	Deerfield, IL	
Koch Industries	Wichita, KS	Ranks #1 in Advanced Materials; KS Corporation; Tim Cesarek, President, KochGenesis has expressed interest in participating in the Center's Advisory Panel or Board
Boeing	Wichita, Chicago	Leader in aerospace eng; strong presence in KS
DuPont	Wilmington, DE	
Dow	Midland, MI	
Corning	Corning, NY	
PolyOne	Avon Lake, OH	
Allegheny Technologies	Pittsburgh, PA	
Ferro Corporation	Cleveland, OH	
W. L. Gore & Associates	Newark, DE	
A. Schulman	Akron, OH	
GrafTech International	Wilmington, DE	
Esterline Technologies	Bellevue, WA	
Brush Engineered Materials	Cleveland, OH	
CoorsTek	Golden, CO	
3M	St. Paul, MN	
Textron International		Leader in aerospace eng

		materials; strong presence in KS
Raytheon	Wichita, KS	Leader in aerospace eng; strong presence in KS
Georgia Pacific Resin, INC]	Decatur, GA	Leader in adhesives for wood and nonwood
AgRenew, Inc	Manhattan, KS	Start-up company on biobased materials and products, 6 SBRIs funds in recent years

Short term commercialization products from KPRC, Pittsburg State University

No.	Technology or products	Commercialization partner	Timeline	IP position	Market size
1	Polyols for polyurethanes	Cargill	In progress	patented	4,000,000 tons
2	Polyacids for polymers by hydroformylation	Cargill	5 years	Know how	50,000 tons
3	Polyols for polyurethanes coatings by ozonolysis	Offered for	2-5 years	Know how	500,000 tons
4	Soy-based polymer concrete	Offered for		Know how	
5	Isocyanate terminated, soy-based prepolymers for coatings and adhesives	Cargill	2-5 years	patented	500,000 tons
6	Natural and synthetic fiber composites with soy-urethanes	Offered for		Know how	100,000 tons
7	Vegetable oil-based two-component adhesives	no	2-5 years	To be developed	100,000 tons
8	Polymeric oils for coatings, inks	Cargill	2-5 years	Not developed	50,000 tons

Appendix E

Relationship to Senator Pat Roberts' Material Science Advisory Committee on Science, Technology and the Future

Senator Roberts' material Science Advisory Committee, chaired by Kenneth J. Klabunde (KSU) and co-chaired by Judy Wu (KU) is charged with creating an atmosphere in Kansas that encourages progress in Materials Science. The proposed KCBIMT perfectly fits into this charge, and therefore is strongly supported by this committee.

Appendix F

Relationship to Senator Pat Roberts' Aviation Task Force on Science, Technology and the Future

Senator Roberts' Aviation Task Force, chaired by Robert Waner (The Boeing Company), is tasked with ensuring the global competitiveness of the Kansas aerospace industry. Top priorities of this task force include continued investment in technology developments, to include manufacturing and maintenance of advanced materials, rapid insertion of advanced materials, materials joining technology, structural health monitoring and smart materials technology, and validated sensor and unmanned aircraft technologies. Synergistic activities within the first four categories and the KCBIMT are obvious. The latter category, involving unmanned systems and sensor platforms, is equally synergistic as the emerging intelligent airborne platforms are certain to be the first adopter of biologically-inspired devices within the aerospace industry.