Award Specific Terms and Conditions for the EEC-0813570 / 1158833, "NSF Engineering Research Center for Biorenewable Chemicals (CBiRC)", Iowa State University Cooperative Agreement

The terms and conditions stated herein are the minimum requirements to fulfill the responsibilities to achieve the goals expected under ERC solicitation NSF 07-521. All referenced documents including websites are made a part of this Cooperative Agreement. The absence of a compelling strategy for achieving demonstrable impact in and of the key features of a Gen-3 ERC incorporated in this agreement and described in full details in NSF 07-521 is sufficient reason to deny continued funding.

The following includes revisions to the generic ERC terms and conditions that impact all ERCs since NSF 07-521 was issued.

1. Project Description:

The ERC will develop the fundamental knowledge and technology and the academic and industrial partnerships needed to provide a foundation for the U.S. industry to transform from a petroleum-based industry to a renewable resource -based industry. The goal of CBiRC is to enable the transformation of the chemical industry through the optimized coupling of two catalyst types such that a biocatalyst will convert glucose to an intermediate chemical that can be readily converted by a chemical catalyst to the desired chemical product. It will educate a workforce capable of enabling this transformation.

2. Project Governance and Governing Responsibilities:

The Awardee will ensure that an efficient and effective project governing structure is in place throughout the award period to support all critical significant project activities. The awardee will also ensure efficient and effective performance of all project responsibilities by the governing components throughout the award period.

3. Key Personnel:

The following positions are considered Key Personnel and are essential to the work of this ERC. Any contemplated changes in Key Personnel for these positions should be discussed with the NSF Program Officer. Written approval from the NSF Program Officer must be secured before any change is implemented. Any anticipated change

in the people serving as the Center Director or the Deputy Director to be effective within the next performance year must be disclosed in the ERC's annual report, and a succession plan must be provided in the report.

Center Director – Brent Shanks
Deputy Director - Basil Nikolau
Administrative Director- Tonia McCarley
Education Program Director - D. Raj Raman
Pre-College Education Program Director - Adah Leshem
Industrial Collaboration and Innovation Director – Peter Keeling
Diversity Director - Krishna Athreya
International Program Director - Abhaya Datye

In the case of the departure of the Center Director, the lead university and the affected university, in consultation with NSF, will find a replacement suitable to NSF. Before a change is implemented within the lead university, written approval from the NSF Program Officer must be secured. In the case of the departure of (a) the Center Director from the lead university, or (b) one of the PIs from a core partner university, and NSF does not find the person recommended by the Center to be suitable, the Foundation reserves the right to recommend termination of the ERC or the core partner's affiliation with the ERC.

4. Lead and Core Partner Universities:

The NSF Engineering Research Center for Biorenewable Chemicals (CBiRC) is configured as follows: Iowa State University is the lead university in the ERC, and, the Pennsylvania State University, the University of California - Irvine, the University of New Mexico, the University of Virginia, the University of Wisconsin-Madison, and William Marsh (W.M.) Rice University are core partner universities. In the case of inadequate performance at the lead university or at any of the core partner universities, the Foundation reserves the right to recommend termination of, respectively, the ERC or the core partners.

5. Requirements for the Implementation of the Key Features (Revisions Since the Release of the ERC Solicitation:

a. Strategic Research Planning and the Research Program:

(1) Support for the Research Experiences for Undergraduates Program (REU) program, at a minimum of $42K per year, will be provided using ERC base budget funds. The ERC may seek an REU site award under the REU Program Solicitation to augment these funds. The ERC also may augment base REU Program support through a combination of REU supplemental awards to individual ERC faculty as long as those students have an interdisciplinary ERC experience with exposure to industry.

(2) U.S. Student Involvement at Foreign University Partners: If there is a large number of U.S. ERC students who work in the foreign partner university(ies)' laboratories resulting in a large accrual of materials costs, the ERC may provide a subaward to that foreign partner to cover those costs.

b. University Education:

The ERC's university education program will function with a governing hypothesis of how to develop creative, innovative, and globally competitive engineers, will implement a set of activities and experiences designed to impart those characteristics to students, and will assess the impact of the program in achieving the desired characteristics in the impacted students.

c. Pre-college Education Program:

Support for the RET Program, at a minimum of $42K per year, will be provided using ERC base budget funds. The ERC may seek an RET site award under the Program Solicitation to augment these funds. The ERC also may augment base RET Program support through a combination of RET supplemental awards to individual ERC faculty as long as those teachers work in ERC laboratories and have an interdisciplinary ERC experience. A short-term workshop designed only to inform pre-college teachers about engineering concepts may also be carried out but not in lieu of the required RET program.

d. ERC Innovation Ecosystem:

(1) The ERC's industrial/practitioner partnership program will be governed by an ERC-wide membership agreement, including a uniform IP policy for ERC-generated IP at the lead and each of the ERC's partner universities. The membership agreement defines the scope and function of the ERC's partnership with industry/practitioner organizations, the types of membership such as full, affiliate, contributing, etc, the respective membership fees, and the ERC's Intellectual Property (IP) policy. The ERC will develop an IP policy that facilitates the roles of industrial partners in Gen-3 ERCs and be flexible in recognizing IP jointly developed by faculty in different universities or that developed by joint industry and university research.

(2) Foreign firms may be members of the ERC as long as they participate in accordance with the same membership agreement as U.S. firms. Domestic and foreign member firms/practitioner organizations will contribute financially to the ERC and will have first rights of refusal for ERC-generated Intellectual property (IP) if they are full members.

(3) The ERC will function with an Industrial Advisory Board (IAB) involving all of its Industry/practitioner members. The IAB will meet at least twice a year, carry out an annual analysis of the ERC's strengths, weaknesses, opportunities and threats to survival (a SWOT analysis), and participate in the annual NSF review of the ERC's performance and plans. During the meeting with the NSF site visit team, the Chair of the IAB will present the IAB's SWOT analysis to the review team and discuss the findings. The SWOT will be updated annually and progress of the ERC in addressing the SWOT will be discussed with the NSF site visit team as well. The Chair and the IAB members also will discuss the annual SWOT analysis with the ERC Director and the ERC Leadership team to determine appropriate future strategies to deal with the weaknesses and threats.

(4) Industrial consortia may join the ERC, but benefits of membership do not accrue to firms that are consortia members, unless they are also paying membership fees to the ERC as members separate from the consortia.

(5) Throughout the course of the ERC's funding by NSF, the Center shall continue to develop and refine its technology transfer and innovation strategy and its Intellectual Property policy, the latter in accordance with NSF's Intellectual Property guidelines (NSF Award and Administration Guide, Chapter VI.D., "Intellectual Property") and the Awardee's policies.

(6) Industrial membership fees are treated as Program Income, and must be allocated for use for Center purposes. Industrial membership fees that are not expended in the year in which they are received must be placed in a Center account and reported to NSF and industry as 'unexpended funds' that are held in reserve for future use. Progress reports on the expenditure of these funds should be included in the Center's annual report and reported to IAB during the IAB meetings. Industrial members may provide additional support for activities such as sponsored research projects, equipment donations, intellectual property donations, or educational grants.

(7) Costs for organizing meetings with industry members will be borne by the ERC or the participants through a registration fee, as deemed appropriate. Costs for attending these meetings by industry members will be borne by their organizations.

(8) All ERCs will have member firms engaged in translational research through sponsored projects, and small firms carrying out translational research supported by funds from the ERC Program's Translational Research Fund or other non-ERC, non-member, non-university sources for ERC-generated Intellectual Property (IP) that member firms do not license,

(9) In addition, the ERC will develop and nurture the innovation

ecosystem for the purposes of accelerating the translation of knowledge into innovation, by:

(i) Stimulating member firms to support sponsored projects for the purposes of translating center-generated IP to commercialization,

(ii) Forming collaborations with small firms for the purpose of translating ERC-generated IP to the marketplace, if member firms do not license the IP - (This should be done via licensing IP, knowledge transfer to the firm, and/or securing translational research funds to accelerate commercialization of the technology by the small business in partnership with the ERC. Translational research funds could be secured from the ERC Translational Research Fund and/or from funding from other non-ERC/non-member/non-university sources);

(iii) Building partnerships with federal, state, or local government programs designed to develop entrepreneurs, support start-up firms, and otherwise speed the translation of ERC-generated knowledge and technology into practice and products; and

(iv) Leveraging technology commercialization opportunities offered by the federal Small Business Innovation Research (SBIR)/Small Business Technology Transfer Research (STTR) programs. The ERC will include analyses to determine the most effective methodologies to use to achieve these innovation goals through these types of partnerships.

(v) In reference to 9(ii) above, ERCs will classify their IP generated from research under the scope of the ERC's strategic plan as core IP (IP resulting from center-controlled unrestricted funds) and Project IP (IP resulting from restricted funds that flow through the center or flow directly to a PI). For Core IP and Project IP, the full member firms/practitioner organizations or the sponsoring firm/ practitioner organization, respectively, will be offered the first option to negotiate a license. If there is no license forthcoming in either case, the IP can be offered to a non-member small firm and a partnership formed between that firm and ERC faculty to carry out translational research to accelerate product development. Support for a translational research project to accelerate product development can be sought from NSF through the ERC Translational Research Fund; in that case, the small firm would be the submitting organization, with a subaward to the ERC faculty. In

addition, in that case, the university must screen the project for ERC faculty, Industrial Liaison Officers (ILO) and/or ERC Executive Management personnel conflicts of interest. When conflicts are disclosed for any of the above three categories of personnel, the university impacted must develop a conflict management plan for each disclosure.

(vi) In the case of a conflict, there will be a conflict of interest management plan. Progress and impacts of the project would be reported in the ERC's annual report. Because NSF would support such a project as an associated project outside the center's core funds, any additional IP developed from that project would not revert to the university or member firms.

e. Student Leadership Council. The SLC is responsible for organizing student activities to achieve the ERC's goals for research and education. The SLC will be comprised of undergraduate and graduate students and will have a Chair and a Co-Chair. The Chair will serve as a member of the ERC's Leadership Team. The SLC also is responsible for carrying out a SWOT analysis of the ERC and communicating the results to the ERC Director, the ERC's leadership team, and the NSF site visit team.

6. Programmatic Activity Requirements:

a. Joint NSF-Awardee Activities:

(1) The ERC will participate in evaluation and other types of studies of the ERC Program initiated by NSF. Such studies include but are not limited to the outcomes and impacts of the ERC Program. The ERC will also participate in workshops organized by NSF to study various issues common to the system of centers. Costs for attending these meetings must be included in the budget submitted to NSF.

b. Electronic Access: The Awardee shall establish and maintain an electronic access capability via the Internet to transfer the quantitative and qualitative data to an NSF database. The access to this electronic information will be protected and only NSF will have and grant access. The Center will establish a WWW "Home Page" containing some elements with public access to make available any information about the Center's goals, activities, and accomplishments. The Center will develop and use an identifying logo that is consistent with the Awardee's policies and procedures and approved by the Awardee as a graphic identity to be used on brochures, newsletters, on the Center's WWW "Home Page," etc.

7. NSF Ongoing Project Oversight:

The Awardee will ensure full commitment and cooperation among the governing structure components, and all project staff during ongoing NSF project management and oversight activities. The awardee will ensure availability of all key institutional partners during any desk or on-site review as well as timely access to all project documentation. As a minimum requirement, the Center Director will meet annually at NSF with the NSF ERC Program Officer assigned to the ERC for oversight to discuss progress and other issues. The timing of the visit is to be determined by mutual agreement between the Center Director and ERC Program Officer.

a. Annual Review: NSF will carry out annual site visits to review the progress and plans of the Center. Renewal reviews will be carried out in years three and six. Based on the performance of the ERC, and in consultation with the ERC Director, the NSF Program Officer may determine that an annual site review is not necessary. In that case, the Center Director and a team of key individuals may visit NSF to update the NSF Program Officer and other NSF staff on progress and plans of the Center. For the purpose of the annual review, site visits will be conducted a minimum of six weeks prior to the anniversary date of the award to review performance and to provide advice to the ERC. The level of continued NSF support will be negotiated with the Awardee annually and will depend upon a review of progress through the annual site review or other means, the performance metrics, the industrial support level, the Program Officer's assessment of progress, and the availability of funds for the program.

b. Renewal Proposal Review: If a renewal proposal is submitted during the sixth year of the Center's operation, the ERC will be evaluated in the manner described above to determine whether NSF will continue to support full ERC operations or provide decreased funding to phase out NSF support of the ERC over Years 7 and 8 of the Center's operation. If NSF decides to continue full ERC operations, a new level of funding support will be negotiated for years 7 and 8 and two years will be added to the agreement to extend it through year 10. If the Awardee chooses not to submit a renewal proposal, NSF support to the ERC will be phased down over the two-year period covering Years 7 and 8 of the Center's operation.

c. NSF will specify the format of the progress report/renewal proposal, the review process, and review criteria approximately six months before the date agreed upon for submission.

d. Termination of the Cooperative Agreement. NSF's agreement with a Center might be terminated as a result of an annual review indicating insufficient progress in organizing the ERC to achieve its vision, or not addressing one or more key features of the Center. In the case of termination, NSF support to the Center will be phased down over the next one or two years.

e. NSF may carry out a summative site visit at the end of the 10th year of support to determine the long-term value added by the ERC.

f. After the end of the Cooperative Agreement with NSF, NSF expects the ERC to continue in a self-sufficient mode, maintaining the ERC culture with support from funds outside the ERC Program. Under no circumstances will the ERC receive ERC Program support to continue its full center operations after the Cooperative Agreement expires, although it may receive ERC Program support through subawards from other ERCs or through special purpose awards designed to capitalize on past ERC Program investments.

8. Reporting Requirements:

Awardee will provide *ad hoc* and regular reports as designated by the NSF cognizant Program Official, with content, format, and submission time line established by the NSF cognizant Program Official. The Awardee will submit all required reports via FastLane using the appropriate reporting category; for any type of report not specifically mentioned in FastLane, the Awardee will use the "Interim Reporting" function to submit reports.

a. Annual Report:

The Awardee shall submit an Annual Report which will contain specific information including, but not limited to, the following: the progress and plans of the ERC in all areas in achieving its vision with supporting data developed from the data submitted to the ERC Program's data base of indicators of progress and impact, information on revenues and expenditures, and proposed budgets. The annual report should also include plans, quantitative information on performance and the ERC's impact on diversity. The annual report is due at least five weeks prior to the annual site visit and at least 11 weeks prior to the anniversary date of the award. The annual report must be prepared according to the online document "Guidelines for Preparing ERC Annual Reports and Renewal Proposals," which is available at: https://www.erc-reports.org

b. Data Tables:

NSF maintains a database, ERCWeb, to collect and report quantitative and qualitative data for all of the ERCs. Each center is required to enter data into the database annually as instructed the "Guidelines for Preparing ERC Annual Reports and Renewal Proposals" and the "Guidelines for ERCWeb Data Entry." Both documents can be found at the website https://www.erc-reports.org. Many of the data tables required in the Annual Report are produced from the data submitted to the ERC

database. The Center will print these tables directly from the database website and use them in their respective Annual Reports. Details, data collection requirements and procedures for entering data are available in the "Guidelines for ERCWeb Data Entry" document.

c. Renewal Proposal:

In lieu of the sixth-year annual report, the Awardee may submit a renewal proposal that contains a cumulative progress report covering the period from the beginning of the fourth year to the date of submission of the renewal proposal, a request for support for years seven through ten, and plans for center activities during that last four-year period of this Cooperative Agreement. The progress report/renewal proposal is due at NSF by a date agreed upon between NSF and the Awardee. If the Awardee chooses not to submit a renewal proposal, NSF support to the Center will be phased down over the two years remaining in the period of support provided by this Cooperative Agreement.

d. Summative Report:

If NSF decides to carry out a summative review of the long-term impact of the ERC, a summative preliminary final report covering the period from the beginning of the Center to the anniversary date shall be submitted to NSF at least five weeks prior to the final 10th year summative site visit. More details are available at https://www.erc-reports.org on the "ERC Library" link.

e. Final Report:

A final report prepared according to guidelines provided by the ERC will be due within 90 days of the expiration date of this Cooperative Agreement. Guidelines for the ERC final report are available on the following site: https://www.erc-reports.org on the "ERC Library" link.

In addition, to assist NSF in evaluating the ERC programs, the PI must also respond to the request for information about project outcomes following the end of the award period. These include the project's impact on workforce needs, awards and other measures of the quality of the project's products, including project technology transfer results not reported in prior years, but due to the ERC investment of prior years. NSF will provide guidelines for the collection and reporting of data and project information.

9. Diversity Strategic Planning:

The leadership, faculty, and students involved in an ERC shall be diverse in gender, race, ethnicity and persons with disabilities at levels that are benchmarked against the academic engineering-wide national averages. The faculty and staff of the ERC and the

administrations of lead and partner universities receiving NSF funding shall devote the time and effort required to ensure that the diversity of the Centers' leadership teams, faculty, and students at all levels serves as a model for diversity within each institution and for the nation as a whole. The ERC will prepare and execute diversity strategic plans in collaboration with the home departments of the ERC-affiliated faculty. These plans shall articulate the ERC's diversity goals and intended actions but need not specify quantitative targets. The ERC also will be multicultural through the involvement of faculty and students from other countries by virtue of their role as faculty or students in the ERC's institutions and, through the involvement of faculty and students from the foreign partner universities. The involvement of foreign faculty and students also is expected to be diverse, representing a broad spectrum of cultures and countries. In fulfilling its obligations under the agreement and in compliance with the requirements of federal law, no university receiving federal funds will employ quotas or set-asides based on race.

Each ERC will:

a. Demonstrate the existence of a partnership among the affiliated Deans of Engineering, other Deans, and the chairs of departments of the affiliated ERC faculty to increase the diversity of the Center's leadership team, faculty, undergraduate and graduate students, and graduates over the duration of NSF's support.

b. Include as the lead or one of the domestic partner universities a university that serves large numbers of students predominantly underrepresented in engineering in the U.S. (i.e. women, African Americans, Pacific Islanders, Native Americans, Hispanic Americans, or persons with disabilities). The ERC may also develop non-core partner outreach connections with the same types of institutions.

c. Develop and strengthen long-term core or outreach partnerships with predominantly female, African-American, Native-American, and Hispanic-American serving institutions and/or institutions serving large number of these underrepresented students who are majoring in engineering and science programs.

d. The ERC may also, but is not required to, develop outreach connections with NSF programs focused specifically on increasing diversity of engineering students and faculty through the involvement of women, underrepresented racial minorities, and Hispanic-American students. This may include connections with one of the NSF's Louis Stokes Alliance for Minority Participation (LSAMP), and/or with one or more of the NSF-sponsored awardees focused on diversity such as the NSF Alliances for Graduate Education and the Professoriate (AGEP), Colleges and Universities that serve predominantly Native American Populations, and other ongoing NSF programs serving underrepresented groups.

e. Focus the Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs on increasing diversity.

10. Key Features:

a. Vision of the ERC:

The vision of CBiRC is to transform the chemical industry by integrating biological and chemical catalysis systems to produce biorenewable chemicals. CBiRC will provide educational programs, which attract a diverse set of students into the engineering field, and produce a new cadre of globally-competitive college graduates capable of designing integrated chemical/biological processing systems.

b. ERC's Strategic Goals:

The ERC will use the ERC Program's 3-plane strategic planning chart to display its strategic goals and the integration of its research program, accompanied by a milestone chart depicting the major deliverables through time and their interdependencies. CBiRC's strategic plan will enable the ERC to create a broad-based technological framework that can establish the engineering and intellectual infrastructure to generate a flexible system for producing a large number of biorenewable chemicals.

The driving force for the ERC is the development of a sustainable biorenewable chemicals industry that is carbon neutral, thereby contributing to the sustainability of our society and economy. The CBiRC Three-Plane Strategic Plan represents CBiRC's strategic plan to achieve this goal. The systems drivers for this ERC are the carboxylic acid, pyrone and bifunctionals testbeds. System-level life-cycle analyses will be carried out at the testbed stage to determine the sustainability of the processes in terms of reliability, cost, and environmental impact. These systems efforts drive a body of fundamental research in the underlying knowledge base needed to achieve the vision. The knowledge gained at this level feeds into the enabling technology, providing the tools for microbial metabolic engineering and new catalytic reaction systems.

c. ERC's Research Goals:

Thrust 1 - New Biocatalysts for Pathway Engineering:

CBiRC will generate a flexible platform for the production of commodity chemical intermediates from biological precursors. That is: CBiRC will develop technologies for generating a series of biologically derived chemicals that will represent a new precursor landscape for producing commodity molecules or final chemical products. This landscape will be established via a new paradigm in combinatorial metabolism based on biocatalysts identified and characterized by Thrust 1 of the CBiRC. These biocatalysts will be accessed from a wide variety of organisms that harbor different polyketide/fatty acid biosynthetic pathways. These metabolic processes offer flexible biochemical conversions that can reiteratively generate a homologous series of alkyl-chains, which carry different chemical functionalities at specific positions of the molecules. Theoretically, these metabolic processes can generate alkyl-chains that range from 3- carbons to 18-carbon atoms; however, the initial focus will be on molecules that are of up to 10- carbon atoms. It is important to note that the focus of the work is not the synthesis of complex polyketides, but using the biocatalytic machinery of the polyketide/fatty acid pathways to produce smaller molecules.

Thrust 2 - Microbial Metabolic Engineering:

While the discovery of new pathways for the synthesis of small molecules with novel structures is a critical first step, significant effort is still required to develop efficient microbial strains in order to produce these molecules in an economically viable manner. The focus of the microbial metabolic engineering thrust is thus to develop microbial platforms using a systems approach to produce small polyketide based molecules by incorporating new synthesis pathways discovered from Thrust 1 at high yields, high rates and high product titers. Specifically, the microbial production platforms will have the following properties:

(i) Integration of new pathways into the production platforms
(ii) Efficient pathway design to allow proper balance between cell growth and product formation
(iii) Balanced carbon and cofactor flow
(iv) Maintenance of robust performance even at high product titers
(v) Robust cell growth, and address scale-up issues with industrial input

Thrust 3 - Chemical Catalyst Design:

Catalytic reactions are typically controlled by chemical processes that take place at various length scales. Moreover, complex couplings can take place between these processes, leading to potentially synergistic effects. Accordingly, an understanding of such couplings is essential for

"catalytic reaction synthesis," which is the identification, development, and optimization of catalytic reactions for new applications, especially those applications that are not simple variations of known catalytic reactions, such as developing new catalytic reactions for production of chemicals and fuels from renewable biomass resources. Important couplings in catalytic reaction synthesis for biomass conversion are expected to be: (1) functional coupling at the active site level; (2) kinetic coupling between active sites in the same reactor; (3) chemical coupling between surface reactions and homogeneous reactions for liquid-phase processes; and (4) thermodynamic and transport coupling between multiple phases (e.g., gas, aqueous, organic liquid, and solid catalyst phases) in complex reactors.

d. ERC's Specific Education Goals:

CBiRC's university education program will function with the following educational hypothesis of how to develop creative, adaptive, and innovative engineers who can serve as technology leaders and succeed in a global economy. Innovative and creative CBiRC engineers will: (1) possess a deep understanding of fundamental principles honed by hands-on experiences in CBiRC's design courses, in the lab, and/or in industrial internships settings – yielding willing tinkerers and critical thinkers who are continuously improving the systems where they work; (2) have a cross-disciplinary education with sufficient breadth to allow serious consideration of alternative solutions, especially the integration of biocatalysis and chemical catalysis; (3) understand economic and environmental constraints are central to the practice of engineering and be capable of evaluating their work based on economic and environmental criteria through CBiRC's Life Cycle Assessment Thrust's work; and (4) be aware of broader issues of sustainability and global ethics through special courses and involvement with the ERC's foreign partners facilitated by the ERC's NSF Partnership for International Research and Education (PIRE) award at the University of New Mexico, which has an ethics component. CBiRC will carry out formative and summative assessment and evaluation to determine the educational effectiveness of this approach to ERC education.

In addition, CBiRC's core educational mission also will provide course materials to facilitate the development of new interdisciplinary graduate minors, concentrations, or options in Biorenewable Chemicals at all partner institutions. Some of the details regarding the logistics of offering the Biorenewable Chemicals Minor and the course listing will vary by institution. However, core courses will be offered using the Virtual Education Center model, so these will cross-institutional borders between partners. For example, at ISU, the interdepartmental Biorenewable

Chemicals Minor will reside within the Graduate College, and be affiliated with CBiRC.

The core course in the Biorenewable Chemicals Minor will cover both biological and chemical catalysis, and will be the primary vehicle for ensuring that CBiRC graduate students are trained in both types of catalysis. This course will be taught by faculty from several CBiRC partners, and will be made available to students at all CBiRC partners via distance education. In addition students will attend an annual meeting of the CBiRC where students in each thrust area will present posters and learn about each other's research findings, thereby gaining a better appreciation for both chemical and biological catalysis of biorenewables.

The ERC will provide innovation and entrepreneurship training experiences through collaboration with the Pappajohn Entrepreneurship Center, venture capital firms, and translational research experience with small start-up firms.

e. Specifics of the Pre-college Education Program:

CBiRC will convey fundamental concepts of biorenewables engineering to pre-college students by collaborating with pre-college teachers to integrate aspects of chemistry, physics, biology and math into middle and high school curricula. This will be done through modules. Three modules will be designed and developed to teach engineering concepts as they relate to biorenewables in the high school or middle school curriculum. The modules will include experiments with readily available materials and will foster open-ended inquiry and problem solving skills. The modules will be used to supplement existing curricula to enhance national science standards and benchmarks. Teachers attending CBiRC Research Experiences for Teachers (RET) programs will be well positioned to make use of any of these three modules in their classrooms.

Teachers who do not participate in CBiRC professional development programs will be able to access guides to the modules through a web portal which will contain a video program/podcast providing background content and a list of materials required for each module. The video program/podcast will be designed not only as a teacher professional development aid, but also for use in the classroom by students. The design of the portal will be aimed at both audiences. Familiarity of students with the technology involved will aid in lowering barriers for their use.

A second program/podcast will train teachers to implement the modules in the classroom. This program's structure will be simple - using narration and visuals to walk the teacher through module use.

This program will be produced as a user friendly self-guided reference.

These modules and programs will be available to teachers nationwide and will be advertised through teacher professional journals as well as at teacher professional conventions e.g. National Science Teacher Association (NSTA). In addition, both programs/podcasts will provide a review for CBiRC teachers.

f. Specifics of the Innovation Ecosystem Program:

CBiRC industrial collaboration and innovation efforts will include partnering with large- and medium-scale established companies as well as start-ups and small businesses. Industrial partners will come from the entire biorenewable chemical value chain, including petrochemical producers, agricultural product processors, chemical catalyst providers, biocatalyst providers, process licensors, etc. For IP not licensed by the member firms, partnerships with start-ups and small businesses will help move technology forward into the commercial realm and provide internship opportunities for CBiRC students. The members will be engaged in the research, education, and technology transfer/innovation efforts of the ERC through the Industrial Advisory Board.

g. Facilities and Headquarters:

A 33,000 ft^2 ($32,000,000) building on the ISU campus dedicated to biorenewables activities has been constructed. CBiRC has 1000 ft^2 of office space in this new building to use as the CBiRC administrative headquarters, and has access to a conference room with telecommunication capabilities. In addition, the Center will have activities in at least 9000 ft^2 of the new building through central use reactor, fermentation, and metabolomics facilities and new faculty laboratories. This new space will provide a centralized focal point to complement the extensive space available in the individual CBiRC faculty laboratories.

h. Faculty Hires:

ISU has committed to hire five new faculty members who will contribute to the center.

i. Special Deliverables:

The issues below were raised during the internal NSF review of the funding recommendation. They need to be addressed during the fourth annual review and subsequently thereafter as needed. The issues are:

1. Development and implementation of a substantial diversity plan;
2. Need for a written resolution of royalty return to the ERC from licensing of IP generated by the ERC's research.