THE BIOECONOMY: BUILDING A CAMPUS-WIDE INITIATIVE FROM A NATIONAL PRIORITY

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I am a participant in a campus-wide initiative at Iowa State University (ISU) called the Bioeconomy. Our Vice-Provost of Research, Dr. James Bloedel, invited me to attend this year's Merrill conference and talk to you about this initiative, which has just wrapped up its second year of activities. I have brought with me some copies of our second annual report, if you would like an in-depth look at our organization. The report can also be downloaded from our website[1] – just Google "biorenewables" and hit "I'm feeling lucky."

Well, we are feeling extremely lucky at the Office of Biorenewables Programs, which manages the Bioeconomy Initiative. President Geoffrey has supported the initiative with new faculty lines. Dr. Bloedel is providing generous operating budgets. We have caught the attention of federal agencies. Even the state has taken notice, or at least opened its eyes.[2]

I say lucky, because we, the affiliated faculty of the initiative, are not prepared for the task at hand. None of us were trained to organize as complex an initiative as this one has proven. As academic researchers we think team work is great as long as we are left to ourselves. We know that a system prospective will help our students land jobs in industry, but we have them focus on our own specialties.

And so I say we were lucky because the Bioeconomy Initiative is inherently systems-oriented, requiring teams of scientists and engineers from many disciplines working together. I cannot offer any sure-fire formulas for assuring success, but I can describe how we muddled through and point out some of the pitfalls that are common in such endeavors.

We define the Bioeconomy as: "An economy in which the energy and raw materials for society are derived from plant-based materials." From these plant-based materials are derived a variety of "biobased products": transportation fuels, commodity chemicals, natural fibers, and electric power. Some people mistakenly assume that biotechnology is the only basis for these transformations. In fact, a variety of thermal, mechanical, chemical, and biological processes are employed to convert plant-based materials into products. For example, biodiesel, one of the early success stories of the emerging Bioeconomy does not involve any biotechnology in its production.

A wide variety of crops and plants, collectively referred to as biorenewable resources, have potential as feedstocks in the production biobased products. These include, not surprisingly, corn and soybeans as well as crop residues and crops dedicated to the production of biobased products, such as switchgrass and hybrid poplar.

The Bioeconomy offers several advantages over the current petroleum economy. The substitution of indigenous agricultural and forestry resources for imported petroleum will improve environmental quality by reducing pollutant emissions associated with fossil fuels. In the United States, the Bioeconomy has the prospect for making productive use of excessive agriculture lands and improving national security by reducing our nation's dependence on resources from politically unstable regions of the world. Finally, biobased products will transform rural development in many parts of the world by introducing new crops and new markets to the agricultural economy.

The Bioeconomy is a national priority. As far back as 1992, federal legislation targeted research in biobased products. A significant milestone was achieved in 1999 with the release of a national vision and roadmap in biobased products. Recent legislation promoting this vision and roadmap includes the Biomass R&D Act of 2000, the Securing America's Energy Future Act of 2001, the Farm Bill of 2002, which includes an historic Energy Title, and the Farm Security and Rural Investment Act of 2002. The federal government has formed a permanent council on biorenewable resources, consisting of the Secretaries of Agriculture and Energy, the Environmental Protection Agency Administrator, the Director of the National Science Foundation and other agency heads, to coordinate national planning for research in biobased products.

The biobased products industry is built upon four major thrust areas: plant science, production, processing, and utilization. Traditionally, academic researchers would approach a problem from the perspective of only one of these thrust areas. However, meeting ambitious national goals of providing at least 25% of organic carbon-based industrial chemicals and 10% of liquid fuels from biobased products by 2020[3] demands concerted and integrated effort in all four-thrust areas.

The Bioeconomy Initiative at Iowa State University was launched in 2002 as one of President Geoffrey's six campus-wide academic initiatives. ISU administration recognized that the Bioeconomy Initiative faced a particularly daunting challenge in getting organized. Most of the other initiatives were "fresh starts" on campus and involved faculty with common visions. The Bioeconomy Initiative, on the other hand, would require collaboration among several centers and programs on campus that already were working on various aspects of biobased products. Each had an inflated view of its own importance in the field of biorenewables and none were eager to make concessions relative to

leadership and direction of the initiative. In short, we were told, the proposed initiative lacked "cohesion." Nevertheless, it is hard to imagine an initiative with more potential for impacting an agricultural state like Iowa, and we were given a chance to rectify this shortcoming.

Our first step was to establish an administrative structure that we hoped would provide cohesion among the various interested parties on campus. Starting another center on campus, as was done by the other academic initiatives, was clearly not a viable approach since it threatened to usurp the biobased programs of existing units on campus. Instead, we created an Office of Biorenewables Programs (OBP) at ISU, which is intended to orchestrate rather than dictate activities in biorenewable resources. The OBP has direct ties to the several units on campus with compelling interests in biorenewables, including the Ames Lab, the Institute for Physical Research and Technology, the Plant Science Institute, the Iowa Agriculture and Home Economics Experiment Station, ISU Extension, and the Iowa Energy Center.

The staff of the OBP is small and service-oriented. As director, my primary duty is to serve as the chair of the Science and Engineering Committee (SEC), which manages the Bioeconomy Initiative. In this I am assisted by Tonia McCarley, a full-time P&S staff person who is responsible for day-to-day operations of the OBP. Jill Euken, an extension field specialist, provides critically important engagement with industry and agricultural producers.

The Science and Engineering Committee (SEC), consisting of faculty members representing diverse academic disciplines, works collectively to realize the goals of the Bioeconomy Initiative. The committee meets as frequently as once a week to make decisions important to sustained momentum of the several activities of the Office of Biorenewables Programs.

The SEC reports to the Executive Council, consisting of Deans and other high-level university administrators, who set strategic direction of the initiative. The Council meets monthly to advise the Science and Engineering Committee.

The Bioeconomy Initiative spans the ISU campus. We have 35 affiliated faculty from twelve academic departments ranging from agronomy to mechanical engineering. The OBP works closely with eight research units on campus. Our external partners include the industrial development association, BIOWA, and the state-funded Iowa Energy Center.

The OBP has several responsibilities. Of course, it is charged with bringing cohesion to ISU's diverse efforts in biorenewables. It serves as the "front door" for external inquiries about biorenewables so that potential clients and partners are assured "one-stop shopping." The OBP administers a newly instituted Biorenewable Resources and Technology graduate program, which I will subsequently describe in more detail. The OBP assists affiliated academic

departments and research units in preparing multi-disciplinary grant applications related to biorenewable resources. It serves as liaison between ISU and biobased industries. And the OBP has been responsible for coordinating the search for new faculty in the field of biorenewables.

Some of the things we don't do are also important. We don't administer contracts and grants, which means we don't take credit for them, either. We don't control infrastructure. We don't have a budget to teach classes. We don't hire or fire faculty. Indeed, we have very little in the way of clout usually associated with academic departments or research centers, but these concessions were important to bringing together the various campus interests in biorenewables.

So how do we get things done? Our early efforts have focused on activities that are mutually beneficial, such as building a graduate training program and developing contacts with biobased industries. However, our successes have reinforced the value of "hanging together" and our attitudes are maybe less parochial than they once were.

The mission of the Bioeconomy Initiative includes research, education, and outreach, which is in alignment with the overall mission of the university. I want to highlight a few activities in each of these three areas.

The basis of our research is technology platforms. A platform is defined as the convergence of enabling technologies into a highly integrated system for transforming a specific feedstock into desired products. The platform teams parallel the way industry conducts research and product development. Platform teams organize faculty and students for cross-disciplinary, systems-oriented research and collaborative learning. To date, seven platforms have been developed: biobased products from vegetable lipids; biosystems analysis and assessment; expression and purification of recombinant proteins; lignocellulosic feedstock development; metabolic engineering of new fermentation products; natural fiber utilization; and syngas fermentation.

By way of illustration, I will describe the syngas fermentation platform, with which I am very familiar. The overall objective of this research is to develop value-added products from distillers' dried grains (DDG), a byproduct of ethanol fermentation via the dry grain milling process. The corn dry milling industry is rapidly expanding in the United States for the production of fuel ethanol. Although this is a promising development for production of biobased transportation fuels, markets for DDG may become saturated as a result. Development of value-added products from DDG will be critical to the future profitability of the corn ethanol industry.

We propose to thermally gasify this high fiber by-product to produce syngas, a mixture of carbon monoxide (CO) and hydrogen (H2), which then

serves as feedstock in an anaerobic fermentation. Although a variety of fermentation products can be produced from syngas, this study employs the bacteria *Rhodospirillum rubrum* to produce polyhydroxyalkonates (PHA), polyesters with potential applications in the manufacture of biobased plastics, fibers, and films.

Although our preliminary assessment suggests that this technology is economically attractive, it faces several challenges. We have recruited faculty with an unusual combination of interests to tackle these problems. I am responsible for evaluating gasification and gas clean-up technologies. Professor Heindel, a mechanical engineer, is investigating the rate at which syngas can be dissolved into the fermentation broth. Professor Dispirito, a microbiologist, is cultivating R. rubrum for maximum yields of PHA. Professor Nikolau, a biochemist, is investigating the metabolic pathways from carbon monoxide to PHA. Michael Duffy, a business specialist at ISU, is investigating market issues related to use of these biopolymers in consumer products. We recently obtained $1 million dollars from the U.S. Department of Energy to investigate this platform.

In support of our teaching and learning mission, the OBP has established the first-in-the-nation graduate program in Biorenewable Resources and Technology, which was approved by our Board of Regents in 2003. In response to concerns that this new major may produce graduates faster than the emerging biobased industries can hire them, we offer the degree as a co-major with more traditional disciplines. Seventeen students enrolled in the first year.

The core of the new curriculum is a course on the fundamentals of biorenewable resources, several laboratory modules, and a seminar course conducted every semester. I have written a textbook, published last year, to support the fundamentals course. We have also offered this course through distance education and we are exploring a web-based curriculum to be shared among several schools offering courses in biobased products.

We consider our outreach activities an essential part of our mission. Without engaging agricultural producers and industry, the Bioeconomy would always remain an academic initiative. Accordingly, we worked with stakeholders in our state to develop an Iowa Vision & Roadmap for a Bioeconomy. We assisted industry in developing a biobased products development association, aptly named “BIOWA.” We provide regular updates to producers and industry through an annual industrial outlook conference. Iowa State has also been a major player in the Federal Biobased Products Preferred Procurement Program, which is developing standards and testing methods to assure that biobased products are manufactured from “renewable carbon” instead of “fossil carbon.”

Although we don’t measure success in something as pedestrian as extramural funding, we don’t mind bragging about the dollars our faculty are

bringing into the university for biorenewables, which amounted to $12 million in FY 2004. This included three awards to ISU from a joint DOE/USDA Biomass solicitation that only made 19 awards in a field of 400 proposals.

I will close by summarizing what I consider to be challenges common to any interdisciplinary research initiative at a university. First, the initiative must receive adequate institutional resources to make a start. Second, a management structure must be adopted that brings cohesiveness among diverse disciplines (I think that this usually requires the administrative unit be located outside academic departments or colleges). Third, the university must be generous in assigning credit for successes; otherwise faculty will return to their academic homes. Fourth, initiatives will require considerable help from university administration in securing cost-share for major grant applications. Finally, if the initiatives include interdisciplinary academic programs, they will need resources for teaching courses and developing curricula.

Our Bioeconomy Initiative has made good progress in meeting these challenges. Much of this can be credited to the confidence that faculty have that their efforts will be recognized and appreciated by the university.

End Notes

1. Office of Biorenewables Programs web site: www.biorenew.iastate.edu

2. National Research Council, "Biobased Industrial Products," National Academy Press, Washington, D.C., 2000.

3. Battelle Memorial Institute, "The State of Iowa Biosciences Path for Development: Economic and Core Competency Analyses," March 2004.