Communication

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Genome Management Information System: A Multifaceted Approach to DOE Systems Biology Research Communication and Facilitation

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Project Goals: Help build the critical multidisciplinary community needed to advance systems biology research for DOE energy and environmental missions and foster industrial biotechnology. The Genome Management Information System (GMIS) contributes to DOE Genomics:GTL program strategies and communicates key GTL scientific and technical concepts to the scientific community and the public. We welcome ideas for extending and improving communications and program integration to represent GTL science more comprehensively.

Concerted communication is key to progress in cutting-edge science and public accountability. With support from the Department of Energy's (DOE) Office of Science, the Genome Management Information System (GMIS) has for 20 years been the main communication resource supporting the Human Genome Project (HGP). However, since 2000 our primary focus has been to help plan, and communicate DOE's Genomics:GTL (GTL, formerly Genomes to Life) program enabled by the HGP. The goal of GTL is to attain a predictive, whole systems–level understanding of microbes and plants to help enable biobased solutions to DOE missions. Our mission is to work with DOE staff and the broad scientific community to communicate biological science challenges and findings to stimulate advances at interdisciplinary interfaces, democratize access to the growing bounty of resources and data, and drive more-informed scientific and societal discourse. Our goals focus on three areas: (1) facilitate GTL planning, research, and communication; (2) respond to communication needs of related projects; and (3) communicate about DOE genomics research and potential applications.

Technical communication integrating all facets of GTL research is critical for spurring innovation at the most rapid pace and at the lowest cost. Such communication is important to achieving DOE missions and, ultimately, fostering U.S. competitiveness through growth in the industrial and environmental sector of the biotechnology industry spurred by DOE genomics research.

Throughout the HGP (1989 to 2003), GMIS strategic networking and communication helped promote collaborations and contributions from numerous fields and reduced duplicative scientific work in the growing genomics community. GMIS staff and the resources we created became the primary "go-to" source for information on all things genomic for much of the scientific world, the media, and the public. A large collection of, informative literature; websites; large-format exhibits; and graphics forms the core of these resources, which are assessed frequently for value, timeliness, and cost-effectiveness. Hundreds of thousands of document copies have been distributed. In addition, GMIS websites annually receive some 20 million page views (224 million hits), many from people who are just learning about genomics and systems biology. Through our resources, networking at various professional scientific and related education meetings, and partnerships, we continue to broaden our reach and focus the attention of those in the national media, government, academia, industry, education, and medicine on DOE genomics and systems biology research.

For the scientific community, communication and research information integration are even more important for GTL than for the HGP, which relied on one dominant technology—DNA sequencing—and produced one major data set—DNA sequence. This new generation of biology is more complex and involves a wider array of technologies, many just emerging, with new types of data sets that must be available to a larger, more diverse research community. Moreover, disparate groups of interdisciplinary scientists must be engaged to achieve the productive dialogue leading to research endpoints that will ensure the success of GTL. The stakes are high: GTL resources and data have the potential to enlarge the research community working on biotechnological approaches to DOE missions, resulting in more rapidly evolving scientific thinking and progress in these and related areas of critical global importance. Communication strategies must be dynamic and evolve along with programmatic needs.

Since 2000, GMIS GTL communication and research integration strategies have included helping facilitate scientific workshops to develop GTL program plans; producing GTL symposia at national scientific meetings; and creating numerous informational resources and tools used by scientists, program administrators, and others. Research plans and reports we have produced with the research community are: *DOE Genomics:GTL Roadmap: Systems Biology for Energy and Environment* (August 2005), *Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda* (June 2006), and *Carbon Cycling and Biosequestration: Integrating Biology and Climate Through Systems Science* (December 2008). Other work in progress includes reports from two

workshops—on GTL computing (knowledgebase) and on biofuels sustainability as well as this abstracts booklet. We also continuously update and enhance GTL's web presence.

In addition to helping drive communication within the scientific community, GMIS will continue to leverage the high level of public interest in genomic science with our established and future resources to inspire a similar wonder at the challenging new task before us: Learning how genomic "parts" (i.e., genes, regulatory components, and networks) work together to produce the processes of life. GTL pursues this grand scientific challenge via investigations in microbial and plant systems, whose sophisticated biochemical abilities are just now being understood and tapped. We will help communicate the excitement of these investigations and their potential applications within the growing interdisciplinary research community and to broader audiences.

> "Interdisciplinary research…is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." [National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, *Facilitating Interdisciplinary Research*, The National Academies Press, Washington, D.C., 2005.]

Ethical, Legal, and Societal Issues

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Intellectual Property and U.S. Public Investments in Research on Biofuel Technologies

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Project Goals: We propose to characterize the IP landscape underlying biofuel research and development as it exists globally today. This will entail a systematic analysis and the creation of an IP database in this technology sector which captures both public and private ownership of patents. We anticipate that this "universe" of IP will encompass research in mechanical engineering, chemical engineering, microbiology, fermentation science, biochemistry, genomics and plant sciences. This analysis will provide an assessment of the structure of IP ownership between the private and public sectors, the identification of key private and public sector players in the biofuel sector and the identification of fundamental technologies that may represent barriers for further technological development.

Increased interest in the replacement of fossil fuels with biofuels to combat global warming and increase national security has resulted in a surge in biofuel research whose outcomes are adding to an already complex intellectual property (IP) landscape. An understanding of the biofuel IP landscape can be used to better inform policy makers, sponsors, institutions and researchers to promote and conduct commercially viable research, which will support the maximization of returns on research investments. To increase this understanding we, at the Public Intellectual Property Resource for Agriculture (PIPRA) group, are mapping the IP landscape of biofuel technologies focusing on bioethanol production from cellulosic biomass. This landscape will be used to analyze global patenting activity including identifying the predominant patent applicants, technology advances and geographical patenting trends.

Bioethanol can be produced from lignocellulosic biomass by either enzymatic hyrdolysis (saccharification) of the plants' polysaccharides to sugars and then fermenting the sugars to ethanol; or by converting the lignocellulosic biomass to syn gas and catalytically converting the syn gas to ethanol. We have completed an exhaustive survey of patents on technologies used in lignocellulosic derived bioethanol production via saccharification and fermentation. This survey identified approximately 1400 patents and patent applications (66% saccharification, 26% fermentation and 18% general processes). Of these, approximately 60% are related to enzyme DNA and protein sequences, and enzyme expressing organisms. Overall, the public sector owns approximately 25% of this IP. In every technology category, the private sector is the major IP owner; except in the category "organisms used in fermentation". In this category, over 90% (122) of the patents and applications are owned by the public sector.

The United States is a major source of innovation in the lignocellulosic biomass saccharification sector. The top recipients of patents in the private sector are Genencor, Novozymes and Novo Nordisk; and in the public sector, the Midwest Research Institute, Hebrew University of Jerusalem and the University of Florida. All but two are United States companies and institutions. Genencor owns the largest IP portfolio, however, over 50 assignees are active in this technology arena. Also, approximately 50% of all patents are applied for in the United States reflecting the large numbers of US assignees and the potential return on investment for a successful biofuel due to the massive consumption of transport fuel in the United States. Our preliminary analysis of the IP landscape associated with the saccharification and fermentation of biomass identified a healthy, competitive landscape in which no single company monopolized the IP.

PIPRA is a not-for-profit organization whose objective is to support innovation in public sector agriculture research institutes for commercial and humanitarian uses, by providing a wide range of technical services for improved IP management. These services include the provision of enabling technologies, generation and analysis of IP landscapes, educational services and the facilitation of licensing and material transfer agreements with member institutions. PIPRA comprises 45 institutional members in 14 countries.

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Implications of Alternative Intellectual Property Rights Management Approaches

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Project Goals: This project will study intellectual property rights topics at the DOE's three Bioenergy Centers and will carry out research to explore the general applicability of the research findings for other, related R&D centers. We will produce papers describing intellectual property rights management practices at the Centers including patenting, licensing, and technology transfer activities.

We will also produce papers describing the general applicability of the findings, within the context of the changing patent landscape and efforts by Congress to reform the patent system. Finally, we will generally support the ORNL ELSI SFA on Intellectual Property Rights topics, with initial efforts directed at the ORNL CNMS.

DOE maintains a vigorous technology transfer program as a key element of its IP activities. As part of the management strategy for administering its Bioenergy Centers, DOE has issued a set of Principles to guide IP practices for new findings emanating from the Centers. The Bioenergy Centers, in turn, have responded with Management Plans for implementing the Principles. The Principles and Plans are innovative, far-reaching and represent a departure from past practices. If successful, DOE might consider them for other similar partnered research ventures. For these reasons, and because they are "zero-based," that is, instituted from the initiation of the Bioenergy Centers Program, the Plans offer a unique opportunity to document how they are implemented, how the incentives they embody influence research partners and potential licensees, and the extent to which they could be adjusted for application to other situations.

However, DOE's changing policy for managing intellectual property rights is taking place within an evolving national patenting landscape that may hold special implications for the development of science and technology. Just as advances in gene sequencing technologies led to incentives for genomic researchers to patents human expressed tag sequences a practice that threatened a potential anticommons, wherein large numbers of patents could reduce access to the human genome, trends in patenting may expand the challenges in seeking patent protection and licensing patents that are issued. In general, the breadth of patentable subject matter is increasing and the scope of individual patents is decreasing, both of which lead to larger numbers of patents. Patent licensing strategies are also changing with patent holders and patent seekers each taking into account opportunities to exploit bargaining advantages. Common property rights organizations, such as patent pools or cross-licensing arrangements are being widely explored. This overall phenomenon is sometimes described as a patent thicket

To ensure the broadest possible applicability for our work we are therefore both gathering data and considering concepts to generalize our findings. Over time we intend to explore patenting issues across other DOE R&D institutions in an effort to ensure the best available information is used both in policy making and in technology transfer programs.

The Biofuels Revolution: Understanding the Social, Cultural, and Economic Impacts of Biofuels Development on Rural Communities

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http://www.ksu.edu/sasw/kpc/biofuels/project_doe.htm

Project Goals: The goal of this project is to provide a better understanding of the socio-economic and cultural implications of biofuels development for rural communities, and to contribute to more informed policy development regarding bioenergy.

A new wave of economic growth is currently sweeping across rural communities in the Midwest region of the U.S., fueled by the construction and expansion of ethanol biorefineries and the expansion of biofuel crop production. While the expansion of the biofuels industry promises to bring jobs and economic vitality to rural communities, it is also creating dilemmas for farmers and rural communities in weighing the benefits of income growth and job growth against safety risks, increased pollution, and the potential of overextending water supplies. Presently, there is little empirical knowledge about the social, cultural and economic impacts of biofuels development on rural communities. This research is intended to help fill these lacunae through an in-depth analysis of the social, cultural, and economic impacts of ethanol biorefinery industry on six rural communities in the Midwestern states of Kansas and Iowa. The goal of this project is to provide a better understanding of the socio-economic and cultural implications of biofuels development for rural communities, and to contribute to more informed policy development regarding bioenergy.

Research Questions:

1. To understand how the growth of biofuel production has affected and will affect Midwestern farmers and rural communities in terms of economic, demographic, and socio-cultural impacts.

2. To determine how state agencies, groundwater management districts, local governments and policy makers evaluate or manage bioenergy development in relation to competing demands for economic growth, diminishing water resources, and social considerations.

3. To determine the factors that influence the water management practices of agricultural producers in Kansas and Iowa (e.g. geographic setting, water management institutions, competing water-use demands as well as producers' attitudes, beliefs, and values) and how these

influences relate to bioenergy feedstock production and biofuel processing.

4. To determine the relative importance of social-cultural, environmental and/or economic factors in the promotion of biofuels development and expansion in rural communities.

Research Methodology
We are in the process of analyzing data from the first three case study communities. The comprehensive methodology includes: demographic analysis; in-depth key informant interviews, three focus groups with farmers, ethanol plant workers, and community leaders; a general population opinion survey of community residents; and a content analysis of local newspapers and print media.

Preliminary Findings
Our preliminary findings suggest that communities have mixed sentiments about the biofuels industry. While many believe that ethanol plants have brought jobs and stabilized local populations, they have not led to an increase in population or overall economic growth in their communities. Many expressed anxiety about biofuels competing for water resources with other potential uses, especially in the more arid parts of Kansas. Moreover, they are concerned about the future of the industry and whether their community will eventually be left with a burden if the industry shifts to second generation biofuels production or other alternative energy sources.

For Additional Information:
Project information and research findings will be available at: http://www.ksu.edu/sasw/kpc/biofuels/project_doe.htm

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Analysis of Global Economic and Environmental Impacts of a Substantial Increase in Bioenergy Production

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Project Goals: The goal of this research is to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. We will build on the unique strengths of GTAP to analyze economic impacts of alternative bioenergy policies at regional and global levels. We will use the TEM model to evaluate the potential for new lands to be brought into production in the wake of biofuel programs, as well as to validate environmental consequences of these policies and check their feasibility from a fundamental bio-geochemical perspective.

Introduction
The global biofuel industry has been experiencing a period of extraordinary growth, fueled (until very recently) by a combination of high oil prices, implementation of ambitious renewable fuel mandates by developed countries (mainly by the US, EU, and Brazil), and government subsidies. This rapid growth has important economic, environmental, and social consequences at a global scale. This research aims to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. The project is built on the unique strengths of the Global Trade Analysis Project (GTAP) based at Purdue University (Hertel, 1997). The project has begun in 2007 and will be completed over a three-year period from the starting point. To achieve the goals of this project we have introduced production, consumption, and trade of grain based ethanol and biodiesel from oilseeds into the GTAP database. We have successfully extended the GTAP modeling framework to analyze production, consumption and trade of biofuel and their byproducts across the world. Given the importance of land use implications of biofuel production we have also augmented our model with a land use module to accurately depict the global competition for land between food and biofuel. While we continuously work to improve quality and reliability of our database and modeling framework, we have used them to assess the global consequences of the biofuel production from different points of view. This poster reviews major results which we achieved so far.

Research Progress and Primary Results
We have incorporated three explicit biofuels sectors (grain-based ethanol, sugarcane-based ethanol, and vegetable oil based biodiesel, in to the GTAP database (Taheripour et al., 2007). We have extended this database in different directions to properly trace the link among the biofuel, vegetable oil, food, feed, agricultural, and livestock industries. Unlike the earlier version, the new database covers biofuel subsidies and tariffs as well. We plan to introduce producing biofuels from cellulosic materials in the next version of the database.

We extended the GTAP modeling framework to evaluate impact of biofuel production on world agricultural markets (Birur et al., 2007). In this work, we extended the GTAP model to handle production, consumption and trade of biofuels. The paper simulates the biofuel economy during the time period of 2001-2006 and isolates economic impacts of biofuel drivers (such as crude oil price, the US and EU biofuel subsidies, and replacement of MTBE) from other factors at a global scale. In addition, this work calibrates the GTAP parameters for the biofuel economy.

Biofuels from grains and oilseeds are produced in conjunction with other by-products such Dried Distillers Grains with Solubles and oilseed meals. These by-products play an important role in analyzing economic and environmental impacts of biofuel production. We have introduced biofuel byproducts into the GTAP modeling framework and have shown that incorporating biofuel by-products in such analyses considerably alters the results in systematic ways in the face of biofuel policies (Taheripour et al., 2008).

We have examined the impacts of the US and EU biofuel mandates for the world economy and their consequences for the global land use changes (Hertel, Tyner, and Birur, 2008). Unlike earlier papers in this field which have focused on the individual, national impacts of biofuel mandates, we have examined interactions among these policies as well. It shows how the presence of each of these policies and their combination influence global markets and land use around the world. This work evaluates impacts of mandates on production, consumption, exports, and imports of 18 groups of commodities across the world, divided into 18 regions.

In a more recent work, we have examined implications of the biofuels boom for the global livestock industry (Taheripour, Hertel and Tyner, 2008). We show that the US and EU biofuel mandates will encourage crop production in both biofuel and non biofuel producing regions, while reducing livestock production in most regions of the world. This work indicates that, the non-ruminant industry curtails its production more than other livestock industries. We also show that the biofuel mandates reduce food production in most regions while they increase crude vegetable oils in almost all regions. We finally conclude that, while biofuel mandates have important consequences for the livestock industry, they do not harshly curtail these industries.

This poster highlights major findings of these research activities. It also presents our next steps towards the projects goals. In the next steps we will extend our database and model to incorporate cellulosic ethanol into our framework, evaluate impacts of biofuel policies on global poverty, and finally combine results from GTAP and other branch of the project which aims to extend the Terrestrial Ecosystem Model (TEM) to evaluate environmental consequences (such as greenhouse gas emissions and water use) of alternative bioenergy policies.

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Issues Associated with the Transition from Science to Application in a Fundamental Nanoscience User Center

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Project Goals: The overarching research question for this task is how best to integrate ELSI scholarship into the conduct of fundamental research and development at the CNMS, thereby enhancing the organization's knowledge of and ability to address ELSI issues before they erupt into potentially polarizing controversies. More specific research- and process-oriented questions this task seeks to answer are the following: 1) Which key stages in nanophase materials R&D have specific linkages with downstream ELSI issues?; 2) Which ELSI-related issues should scientists and science managers be prepared to address, when interacting with different audiences?; 3) What kinds of institutional issues/barriers can be anticipated as the CNMS evolves?; 4) How can ELSI become part of the CNMS "culture" rather than an administrative requirement?; and 5) How can ELSI research and results be made available to members of society as CNMS research and public awareness, knowledge, and concerns evolve over time?

The overarching goal of this project is to integrate Ethical, Legal, and Societal Implications, or "ELSI," into the Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory and, by extension, the larger nanoscience and nanotechnology R&D community. ELSI encompasses the wide array of studies and activities that investigate the "other," non-technological side of the emerging science and technology (S&T). While S&T is oriented toward accomplishing challenging, grand, and sometimes poorly understood outcomes ultimately aimed at enhancing societal well-being, ELSI research can be thought of as studying the interactions between emerging S&T and society as they co-evolve, and predicting the implications and consequences of those interactions on science and society.

ELSI research identifies a suite of concerns about the *potential* positive and negative impacts of emerging S&T on soci-

ety. It also isolates the choices that influence the (positive or negative) impacts *actually* experienced by individuals, subsets of society, or societal institutions. ELSI activities may seek to anticipate societal responses that will follow from earlier choices so as to help sensitize early decision makers about the potential implications of their decision-making processes and resulting decisions.

A major challenge for this project is to conduct ELSI research and related activities in a manner that exploits opportunities presented by the project's close proximity to ongoing CNMS R&D. Our goals are to: (a) sharpen the relevance of ELSI inquiry for the R&D community; and (b) enhance the ability of R&D community to address ELSI issues before they escalate into potentially polarizing controversies. This poster summarizes the implications of one key transition in the nanoscience and nanotechnology life cycle—that of the transfer of fundamental science to explicit downstream applications—and the feedback to S&T resulting from this transfer. The poster describes interim results of interviews with CNMS researchers, highlighting their perspectives on the linkage between fundamental R&D and its downstream uses (demonstration, deployment, decommissioning, and disposal) and their insights into societal issues that should be raised in studying this transition.

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Global Net Primary Production and Bioenergy Potentials and the Environmental Consequences: An Analysis with a Process-Based Terrestrial Ecosystem Model

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Project Goals: To develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. The goal of this research is to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. We will build on the unique strengths of GTAP to analyze economic impacts of alternative bioenergy policies at regional and global levels. We will use the TEM model to help develop the land supply curves and to validate environmental consequences of these policies and check their feasibility from the environmental and land use perspectives.

Our project, entitled "Analysis of Global Economic and Environmental Impacts of a Substantial Increase in Bioenergy Production", is designed to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. The goal of this research is to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. We will build on the unique strengths of GTAP to analyze economic impacts of alternative bioenergy policies at regional and global levels. We will use the TEM model to help develop the land supply curves and to validate environmental consequences of these policies and check their feasibility from the environmental and land use perspectives.

To date, using a process-based biogeochemistry model, the Terrestrial Ecosystem Model (TEM), we have evaluated the global net primary production (NPP) in natural ecosystems as a way to assess global biofuel potentials. We also evaluated the global agricultural NPP with the ecosystem model. NPP is the net amount of carbon captured by land plants through photosynthesis each year considering the effects of atmospheric climate and chemistry changes. We further evaluated the global net ecosystem production (NEP), which is the net carbon exchange between the terrestrial ecosystems and atmosphere. The changes of global NPP and water used during photosynthesis were also evaluated to assess the importance of freshwater in support of NPP production. In addition, we evaluated global emissions of another potent greenhouse gas, nitrous oxide from both natural and agricultural ecosystems, which is accompanied with the production of NPP. As a next step, we will use this ecosystem and biogeochemistry modeling framework to evaluate the alternative bioenergy policies on environmental consequences such as greenhouse gas emissions and water use.