IOWA STATE UNIVERSITY

Plant Sciences Institute UPDATE

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Exploring the virtual plant cell

The development of MetNet as a teaching and research tool is taking place in the Virtual Reality Application Center (VRAC). Here, Julie Dickerson and Eve Wurtele stand inside a virtual plant cell created with MetNet technology.

Picture this: A biologist sits down at a computer and logs into a virtual *Arabidopsis* plant to see how knocking out a gene affects the plant. Or, he or she creates a model that maps out the network of chemical reactions that take place in photosynthesis.

Creating a computerized plant that lets users make predictions before heading to the field is the goal of the MetNet (Metabolic Network Exchange) software being developed at Iowa State.

The project, headed up by Eve Wurtele, member of the Center for Designer Crops, and Julie Dickerson, member of the Laurence H. Baker Center for Bioinformatics and Biological Statistics, embodies an emergent field of study called systems biology—how molecular components within an organism interconnect and are related, with a focus on plant systems.

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BIOENERGYFOCUS

New oil sources

One Iowa State scientist is hoping to strike oil—but not by drilling wells.

David Oliver, a member of the Center for Designer Crops, is researching an untapped source in plant leaves.

"Any good plant biologist will tell you that plants produce oils primarily in the seeds," said Oliver. "Some oil is also produced in the pollen and in the meat around the seed." But, he added, tell a plant scientist there is oil in the leaves and they'll likely disagree. Oliver, disagreed, too, at first, with Nels Lersten, professor emeritus of botany. Lersten discovered early references to oil bodies in leaves and had also observed leaf oils in hundreds of plants himself, the old fashioned way—a slice of plant in a drop of water on a slide, under the microscope.

Lersten believed a change in lab procedure caused a shift away from leaf oil observations. Around 1920, botanists started to embed plant samples in wax, first treating them with alcohol fixatives, which dissolve plant oils.

Oliver's first objective of the research, which is funded by a Plant Sciences Institute Innovative grant, is to prove conclusively that oils exist in the leaves of the boxwood plant. Preliminary data using three different methods shows biochemical evidence of oil in boxwood leaves. To back that data up, leaf samples will

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Staying the course

Despite all the hoopla surrounding bioenergy, there are many detractors who would like to put the matter to rest. At this writing, the price of gas has dropped to nearly two dollars a gallon and Exxon Mobil Corporation announced that "plenty of crude oil remains for world consumption." (*Wall Street Journal*, 9/14/06)

Another unexpected voice of dissention is *Consumer Reports* who ran a cover page story on "The Ethanol Myth" (10/06). They took to task the prospects for E85—complaining about its limited distribution and the poor fuel economy E85 offers for present-day flex-fuel vehicles. The article failed to mention that vehicles tuned for the use of E85 can be made to run nearly as efficiently as gasoline-powered cars.

Consumer Reports does get good marks about the long-standing debate over ethanol's net energy by reporting that recent studies show a net positive energy gain in the production of ethanol from corn grain. However, they do conclude, rightfully so, that cellulosic ethanol, produced from crop residues, is a better fuel for the future.

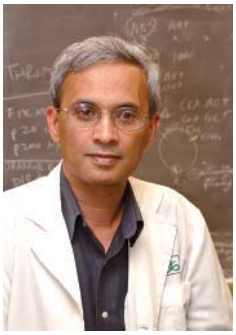
Lester Brown, president of the Earth Policy Institute, took his own shots at ethanol in an op-ed article in the *Des Moines Register* (9/13/06) about "Starving the people to feed the cars?" He tells us that the grain needed to fill up an SUV with ethanol could feed a person for a year. In Brown's view, "It is a battle between the world's 800 million automobile owners, who want to maintain their mobility, and the world's 2 billion poorest people, who simply want to survive."

Again, the development of cellulosic ethanol would address these criticisms head on. It could be a win-win situation if we could utilize crop residues for ethanol and, in that way, our crops could provide both food and energy—without having to starve the people to feed the cars. We Iowans need to stay the course and be leaders in meeting these challenges.

Stephen Howell
Director

New faculty seeks to improve starch production

Corn kernels are like little lunch bags filled with a starchy endosperm and covered with cell layers called the aleurone and pericarp. Filling those lunch bags with starch is of vital importance to agriculture because the starch feeds our animals and our ethanol industry.



Guru Rao is doing fundamental research on a receptor kinase.

Figuring out how the endosperm develops and produces starch, said Guru Rao, requires a fundamental understanding of how plant proteins regulate the process of cell differentiation.

Rao, who arrived at Iowa State this fall as a new faculty member in the biochemistry, biophysics and molecular biology department, is looking at one protein in particular—a receptor kinase that regulates the formation of aleurone cells and influences endosperm development.

"All we know is what the protein looks like," said Rao. "I'm trying to bring in the biochemistry aspect to describe how this protein behaves."

Prior to coming to Iowa State, Rao was a senior research scientist at Pioneer Hi-Bred International for 17 years, where he designed proteins to improve the nutritional quality of grains. He has received 18 patents on various aspects of improvement.

Along with his new faculty position in the department, Rao will be in charge of the Plant Sciences Institute's Proteomics Facility.

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Dickerson describes MetNet as a suite of software that takes enormous amounts of information out of databases and makes it useable by placing it in a biological context. "A lot of these tools are designed to look at pathways," said Dickerson.

Pathways are sequences of chemical reactions that happen within a plant. These pathways control plant development and composition and are actually intricate networks as opposed to linear pathways.

The software allows users to visualize, analyze and model different pathways, creating a "roadmap" of sorts. That "roadmap" can be used to track the synthesis and fate of various chemicals or proteins. Users can also see how different pathways interconnect and affect one another.

"Change one thing and it doesn't just change one pathway," said Wurtele. "There's all sorts of signaling that goes on. For example, if you block one enzyme or add another enzyme, different chemical intermediates can be built up. And these intermediates may go back and signal some genes to be active or others to shut down. We want to be able to predict what will occur."

Other MetNet tools allow the pathway information to be combined with the gene expression profiling data, information that tells if a gene was expressed, when it was expressed and under what conditions.

While the software is still being refined, Wurtele said it is already being used by biologists to develop hypotheses about gene function and recently was used to predict a particular gene important in starch regulation. The function of this gene was independently identified experimentally by scientists in another lab.

The MetNet software development group includes three other faculty members, a postdoctoral scientist and students, bringing together computer scientists, mathematicians and biologists.

The project is funded by the National Science Foundation, Arabidopsis 2010. This NSF effort has the goal of determining the functions of all *Arabidopsis* genes by 2010.

Bringing genotype and phenotype together

The Sequenom MassARRAY® System, a new mass spectrometer machine for genotyping at Iowa State, will speed up genomic plant mapping and lead to more efficient plant breeding.

But more importantly, pointed out Kendall Lamkey, director of the Raymond F. Baker Center for Plant Breeding, it will start to close the gap that lies between genomics research and the application of that research to crop improvement.

"At the crux of the matter is this: for plant breeders to survive in the academic world, they're going to have to get into the application of genomics to crop improvement," said Lamkey, Pioneer Chair in Maize Breeding and chair of the agronomy department. "The flip side is that lots of claims have been made about what great things genomics does, but very little has been put into application."

The Sequenom, funded by the agronomy department and the Plant Sciences Institute and housed in the Center for Plant Genomics, gives scientists who base their research on phenotypes (physical traits) access to high-throughput genotyping (genetic make-up information).

The instrument allows users to identify single nucleotide polymorphisms (SNPs) over a large percentage of a genome quickly—10,000 SNP genotypes can be determined per hour. An SNP is a variation in the DNA sequences of single nucleotides A, C, G, T. The variations, where for instance an A may be in place of a T, differ between varieties. Once mapped out, these SNPs can narrow down regions of the genome that hold traits of interest, or find genes that control the traits.

Patrick Schnable, director of the Center for Plant Genomics and professor of agronomy and genetics, development and cell biology, and his team recently used the Sequenom to validate 900 SNPs from sequenced inbred lines of maize. These validated SNPs will be used to understand the gene activity behind hybrid vigor. Once that's understood, he said, hybrids that hold desired traits can be bred more rapidly. The SNPs will also be made available to other maize geneticists and breeders.

The Sequenom is not specific to plants, Lamkey pointed out. It could also be used by animal breeders and genomicists in the animal science department.

News Briefs

Baum wins Ruth Allen Award

The American Phytopathological Society honored Thomas Baum, director of the Center for Plant Responses to Environmental Stresses, as part of a team that has changed the direction of research into nematodes that attack plants. Baum, chair and professor of plant pathology, received the Ruth Allen Award for Innovative Research along with two researchers from other universities. The three researchers have identified more than 100 secretions nematodes use to infect plants. The long-term goal of the research is to devise new mechanisms against these pathogens.

Kamman takes new post

The first director of the Innovations Development Facility (IDF), Cheryl Kamman, has taken a new post at the Iowa Institute of Hydraulic Research at the University of Iowa. Since 2003 she served as director of IDF, helping scientists write grants, find financing and write plans to turn their research into businesses. IDF is the business and economic development program of the Plant Sciences Institute.

BIO**ENERGY**FOCUS CONTINUED

be tested with high-performance liquid chromatography—mass spectrometry (HPLC-MS), at the Iowa State W. M. Keck Metabolomics Laboratory. Tests will also be confirmed in other laboratories.

If the tests prove oils exist in the leaves of the boxwood, the next step is to find out how much. Oliver will also test the leaves of different species to see if some plants might produce more leaf oils than others.

If it all proves true, Oliver said, the results could lead to a whole new field of research.

David Oliver, professor of genetics, development and cell biology, is researching plant leaves as a new oil source.

Recent research grants

The following 28 new grants totaling $7.18 million were awarded recently to plant science researchers at Iowa State.

Environmental Enhancement Through Corn Stover Utilization
USDA—$1,853,996
(R. C. Brown, mechanical engineering)

ISGA: Functional Genomics of Plant Disease Defense Pathways
National Science Foundation—$505,041
(R. Wise, plant pathology)

A Highly Efficient Homologous Recombination System for Plants
National Science Foundation—$476,631
(D. Voytas, genetics, development and cell biology)

Metabolic Flux Analysis in Plants
Pioneer Hi-Bred International, Inc.—$349,188
(J. Shanks, chemical and biological engineering)

Single Molecule Immunoassay and DNA Screening
National Institutes of Health—$312,742
(E. Yeung, chemistry)

Controlling Yield-Reducing Pathogen Stress in Soybean: Short- and Long-Term Benefits to Stable Production
Iowa Soybean Association—$206,166
(J. Hill, plant pathology)

Breeding General-Use and Specialty Soybeans for Iowa
Iowa Soybean Association—$156,000
(W. Fehr, agronomy)

Effects of Starch and Corn Kernel Structures on the Yield of Ethanol Production
Monsanto Company—$137,136
(J. Jane, food science and human nutrition)

Design of Nanostructured Organic-Inorganic Hybrid Catalysts for Biorenewable Conversion
National Science Foundation—$100,746
(B. Shanks, chemical and biological engineering)

Comparative Evolutionary Genomics of Cotton
National Science Foundation—$72,925
(J. Wendel, ecology, evolution and organismal biology)

Application of Biotechnology to Control Soybean Death Syndrome
Southern Illinois University—$25,400
(M. Bhattacharyya, agronomy)

Functional Genomics of Soybean Response to Cyst Nematode Parasitism Proteins
USDA—$300,000
(T. Baum, plant pathology)

Essential Nature of Fatty Acid Elongation in Plant Development
National Science Foundation—$130,000
(P. Schnable, agronomy)

Osmoprotection of Pseudomonas Syringae during its Association with Plants: Role of the BetT OpuC Transporters
National Science Foundation—$130,000
(G. Beattie, plant pathology)

Barley Coordinated Agricultural Project: Leveraging Genomics, Genetics, and Breeding for Gene Discovery
USDA—$104,095
(J. Jannink, agronomy)

Genetic Improvement of Soybean for Disease Resistance
Iowa Soybean Association—$71,003
(M. Bhattacharyya, agronomy)

Assessing the Value of a Novel Soybean Oil with Mid-Oleic and 1% Linolenic Acids
Iowa Soybean Association—$67,505
(W. Fehr, agronomy)

Seed Quality Evaluation of Corn Germ Plasm Selected for Adaptation to Sustainable Agriculture Production Practices
USDA—$45,839
(S. Goggi, agronomy)

Non-Host Resistance for Engineering Disease Resistance in Soybean
Iowa Soybean Association—$43,752
(M. Bhattacharyya, agronomy)

The Genetics of Genetics: Genes Controlling Recombination in Maize
National Science Foundation—$40,001
(P. Schnable, agronomy)

Iowa Grain Quality Initiative FY06
Iowa Soybean Association—$25,000
(C. Hurburgh, agricultural and biosystems engineering)

IGERT: Computational Molecular Biology Training Group
National Science Foundation—$587,728
(D. Voytas, genetics, development and cell biology)

Biotechnology Test Production, Iowa: Recovery and Purification of Recombinant Proteins from Plants for Therapeutics and Industrial Enzymes
USDA—$429,763
(C. Glatz, chemical and biological engineering)

The Function of Subtilase Genes in Plant Development
National Science Foundation—$280,770
(S. Howell, genetics, development and cell biology)

Discovery of Protein Sequence Structural Function Relationships
National Institutes of Health—$270,992
(V. Honavar, computer science)

Coarse Grained Models of Proteins
National Institutes of Health—$256,944
(R. Jernigan, biochemistry, biophysics and molecular biology)

Acetyl-CoA: The Precursor for High-Energy Phytochemicals
Department of Energy—$130,000
(B. Nikolau, biochemistry, biophysics and molecular biology)

Collaborative Proposal: The Evolution of Genetic Structure in Species-Specific Plant-Insect Relationships: The Relative Importance of Biogeographical and Coevolutionary Processes
National Science Foundation—$70,000
(J. Nason, ecology, evolution and organismal biology)

Plant Sciences Institute UPDATE

The Plant Sciences Institute Update is published four times each year by the Plant Sciences Institute at Iowa State University, 1060 Roy J. Carver Co-Laboratory, Ames, Iowa 50011-3650; phone 515 294-5255.

The Plant Sciences Institute at Iowa State University is dedicated to becoming one of the world's leading plant science research institutes. More than 200 faculty from the College of Agriculture, the College of Liberal Arts and Sciences, the College of Human Sciences, and the College of Engineering conduct research in nine centers of the institute. They seek fundamental knowledge about plant systems to help feed the growing world population, strengthen human health and nutrition, improve crop quality and yield, foster environmental sustainability and expand the uses of plants for biobased products and bioenergy. The Plant Sciences Institute supports the training of students for exciting career opportunities and promotes new technologies to aid in the economic development of agriculture and industry throughout the state. The institute is supported through public and private funding.

To be added to our mail list, e-mail psidir@iastate.edu.

On the Web at http://www.plantsciences.iastate.edu/

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