IOWA STATE UNIVERSITY

Plant Sciences Institute UPDATE

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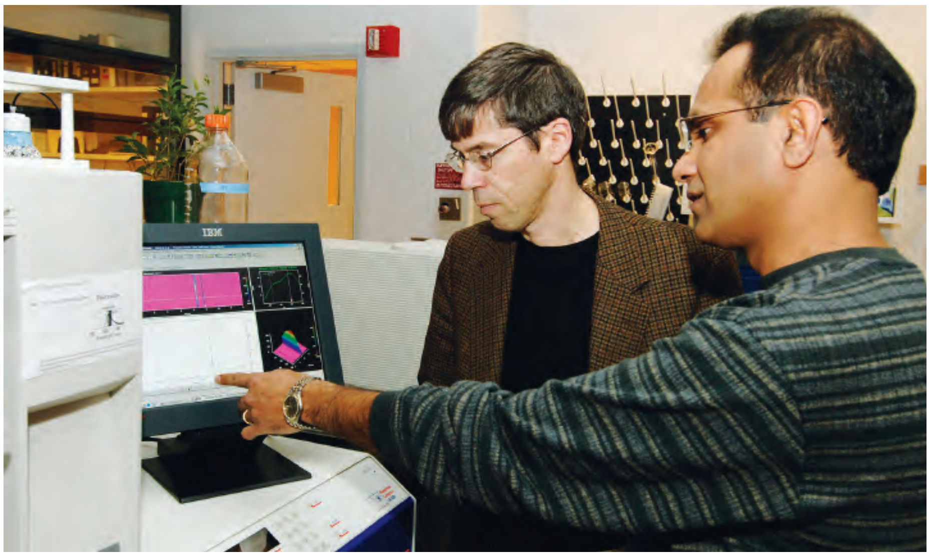
BIOENERGYFOCUS

Lignin and biofuel production



Patrick Schnable and Ramesh Nair are conducting research to make feedstocks convert more efficiently to ethanol.

Plant biomass is being touted as the up-and-coming source for biofuels. There's a challenge, however—biomass, such as corn stover, switchgrass and other feedstocks, is tough and not easily converted to ethanol.

Ramesh Nair, associate scientist in the Plant Sciences Institute, is looking to modify feedstocks so they can be more readily converted to ethanol. He's studying lignin, a compound found in some plant cell walls, such as those found in stems. It acts like protective glue that cross-links cellulose and hemicellulose, important ingredients in making ethanol.

Nair's goal, supported by a PSI innovative grant, is to alter gene expressions to modify lignin composition in corn.

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Shedding light on abscission

It wasn't long ago that days became shorter and temperatures grew colder, two signals that trigger many trees to shed their leaves. "But have you seen those oaks still holding on to their withered leaves?" asked Coralie Lashbrook.

Lashbrook, an assistant professor of horticulture and an affiliate of the Center for Plant Responses to Environmental Stresses, studies abscission: the shedding of plant organs. Her lab takes multiple approaches to determine how plants become competent to abscise in response to environmental or developmental cues. In the case of trees, some species respond to autumn abscission signals, while others like oaks shed old leaves in spring. "We'd like to know how plants make such different decisions to shed or retain organs," Lashbrook said.

One lab project focuses on revealing molecular events that occur in specialized cell layers called abscission zones (AZs). Upon receiving an abscission signal, cells in these rows release enzymes that digest cell walls connecting neighboring cells. Because AZs are located at the base of plant parts, AZ cell separation leads to organ detachment.

"If we can capture just those abscission zone cells that separate in response to abscission signals, we can identify the molecular machinery that is causing that separation. Modifying parts of that machinery should let us improve abscission behavior in economically

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Borlaug's medal

Our congratulations to Dr. Norman Borlaug, a member of the Plant Sciences Institute Board, who will be awarded one of the nation's highest honors, the Congressional Gold Medal. As a native son and a frequent visitor to Iowa, we have heard so much about Dr. Borlaug that his accomplishments are often reduced to platitudes. I want to offer my view on Borlaug and why his deeds are so important.

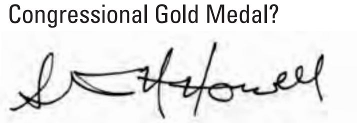
During the early 1970s, several student activist movements swept across the country, and one was called the "relevancy movement." Students agitated for courses that were relevant to the world around them. At the time, I was an assistant professor at the University of California San Diego, and, in response to the movement, my colleagues and I put together a course on food and agriculture.

Two readings for the course were the 1967 book by William and Paul Paddock, entitled *Famine—1975* and Paul Ehrlich's 1968 book, *The Population Bomb.* The authors claimed that we were on the cusp of a Malthusian catastrophe and warned that millions of people would starve to death in the 1970s and 1980s.

Thankfully, the worldwide calamity never happened. Some argued that the authors were alarmists and that the data for their projections were flawed. However, the authors' claims were made credible by the terrible famine in Bangladesh in 1974–75 that took a million lives.

The larger crisis was averted because the Green Revolution began to fill the food baskets of the world. Borlaug and the other founders of the Green Revolution won the greatest battle of any war we've ever fought.

Who could be more deserving of the Congressional Gold Medal?



Stephen Howell
Director

Shedding light on abscission/CONTINUED

important plants," said Lashbrook.

Her lab is currently using technology called laser capture microdissection (LCM) to get to AZ cells of *Arabidopsis* flowers. First developed for isolating cancer cells, LCM can pluck out individual cells or cell types from sectioned plant tissue.

Coralie Lashbrook, assistant professor of horticulture, studies how plants abscise their organs.

Graduate student Suqin Cai optimized LCM to isolate AZ cells from flower stamens abscising in response to pollination. From those cells Cai isolated RNA of sufficient quality and quantity to support gene chip studies of thousands of genes at a time. "The data identifies genes with potentially important roles in controlling abscission," said Lashbrook. "We're testing the impact of modifying their expression on post-pollination abscission."

Practical applications for abscission research are plentiful. Lashbrook noted that oranges are reluctant to let go of trees at harvest and require chemical pretreatments to loosen them. But soybeans drop their flowers in response to many environmental stresses, routinely lowering yield potential.

"If we understand how soybean makes this decision to shed its flowers so easily we could develop strategies to enhance pod set or retention," said Lashbrook. "By the same token, for oranges we could develop strategies to enhance fruit shed. Abscission regulators in *Arabidopsis* may suggest homologs we can modify to improve performance."

Moving the science forward

Iowa State is one of few places in the country to house and maintain such a large cluster of plant databases. Scientists working on them are scattered across campus, but soon a new, 8,000-square-foot facility will bring Iowa State and USDA-ARS researchers from four of the databases together under one roof. The Plant Sciences Institute has helped to make that happen.

The Crop Genome Informatics Laboratory (CGIL), a USDA-Agricultural Research Service facility, will accommodate about 25 people. It will merge scientists from MaizeGDB (Maize Genetics and Genomics Database), PlantGDB (Plant Genome Database), Soybase and the Soybean Breeder's Toolbox, and PLEXdb (Plant Expression Database).

Each database represents a repository of biological information and tools that can point plant breeders to genes with specific agronomical traits. The databases are accessed and used by researchers on campus and around the world. The benefits and goals of CGIL are to enhance communication and collaboration between the scientists.

"All of us are doing very similar things and we usually talk via e-mail or through appointment," said Carolyn Lawrence, USDA-ARS research geneticist. Lawrence is principal investigator of MaizeGDB and an affiliate of the

Nair emphasized the word modify—lignin is needed to help a plant stand up and a reduction in lignin could be detrimental to a plant's survival.

The modified lignin will allow enzymes used in processing plant biomass to more easily access the cellulose and hemicellulose. Prior to fermentation, biomass is pretreated to separate lignin from the other components. One of the goals of Nair's research is to reduce pretreatment costs.

"The main thing that could come from this study is that you won't have to use this expensive and very harsh, environmentally unfriendly chemical treatment to break down lignin," Nair said. The best-case scenario would be to get rid of the pretreatment stage altogether, he added.

"To make biofuels from biomass viable, we need to cut down the production costs at every point," Nair said.

Another goal of the project is to understand the biosynthesis of phenolic acids in order to modify plants to produce less of it. Not all cells have lignin, but they do all have the key ethanol ingredients, cellulose and hemicellulose. In non-lignified cells, such as those in the soft part of a leaf (not the veins), cellulose and hemicellulose are held together by phenolic acids such as ferulic and *p*-coumaric acid.

"Reducing phenolic acid content could help in converting the non-lignified biomass more efficiently to bioethanol," said Nair.

These modifications could also result in silage that is better digested. Silage is the fermented plant material fed to cows and sheep.

Nair brings his expertise in lignin and phenolic acid to this project, which is taking place in Patrick Schnable's lab. In collaboration with Schnable, associate director of the Plant Sciences Institute, he'll determine which genes to alter by using molecular markers and genomics approaches. Once corn plants with modified feedstock composition are developed, Paul Scott, a USDA research geneticist in the agronomy department and a member of Center for Plant Genomics, will test them for efficiency in ethanol production. Nair, Schnable and Scott, are co-principal investigators on this project.

Center for Plant Genomics. "Imagine the ideas and solutions a group of people interacting together face to face might come up with, rather than talking through e-mails or phone calls," she said.

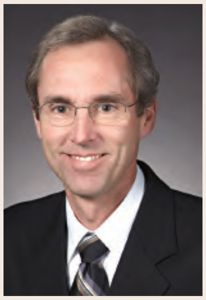
CGIL will also have resources that allow live teleconferencing and space to train database users from off campus. When it opens this spring, it will be home to five newly hired computational biologists.

"Our goal is to advance the science of bioinformatics to the point that we can utilize these huge databases for the benefit of other researchers," director of CGIL and USDA-ARS researcher Leslie Lewis said. "The bottom line is to benefit farmers who are growing soybeans, corn, barley and other crops."

There has been a USDA presence on campus working on plant breeding and genetics since 1922. As crop and plant biological data has been collected over the years, it has been brought together into databases, which have continued to grow and evolve. The basis for Iowa State's current plant database recognition and funding were the *Zea mays* Database, BarleyBase and Soybase. Other databases on campus likely to interact with the ones housed in CGIL are MetNet (Metabolomic Network Database) and MAGI (Maize Assembled Gene Islands).

News Briefs

Miller named CPRES director



W. Allen Miller

W. Allen Miller has been named director of the Center for Plant Responses to Environmental Stresses (CPRES).

Miller is a professor of plant pathology and biochemistry, biophysics and molecular biology, with main research interests in plant virus gene expression. His lab studies genetic variations of yellow dwarf viruses in cereals and how plant viruses usurp the cell's protein synthesis machinery. Miller also uses plant viruses as models to understand how they replicate, knowledge that may apply to human pathogens, such as hepatitis A and C, dengue and West Nile viruses.

Miller has been an affiliate of CPRES since its inception and will lead the center to continue its research focused on how plants respond to biotic stresses, such as those imposed by viruses, bacteria and fungi, and abiotic stresses such as droughts and floods.

"It's a pleasure to be director of a center that is so strong in terms of fundamental research," said Miller, who intends to ensure that the center's state-of-the-art equipment retains its high quality. There are 14 members of CPRES and more than 50 researchers use the center's equipment. Miller also will encourage that CPRES continues its unique in-house seminar series organized by postdoctoral researchers.

Miller earned his Ph.D. at the University of Wisconsin, Madison in 1984. From 1984 to 1988 he worked as a research scientist at Australia's Commonwealth Scientific and Research Organization, Canberra. He joined the faculty at Iowa State in 1988.

Recent research grants

The following 26 new grants totaling $7.8 million were awarded recently to plant science researchers at Iowa State.

Biodegradation of Transgenic Crop Residue
USDA, ARS—$50,000
(J. Coats, entomology)

Sequencing the Maize Genome
National Science Foundation—$43,345
(P. Schnable, agronomy)

High Beta-Carotene Maize to Alleviate Vitamin A Deficiency in Sub-Saharan Africa
The Centro Internacional De Agricultura Tropical (CIAT)—$40,000
(S. Rodermel, genetics, development and cell biology)

TRPGR: Cyberinfrastructure for (Comparative) Plant Genome Research through Plant GDB
National Science Foundation—$960,011
(V. Brendel, genetics, development and cell biology)

Interactive Visualization and Analysis of Large Scale Graphs for Biological Network Modeling
National Science Foundation—$808,353
(J. Dickerson, electrical and computer engineering)

Control of Cap-Independent Translation by a Viral 3' UTR
National Institutes of Health—$214,637
(W. A. Miller, plant pathology)

Functional Genomics of the Biotin Metabolic Network of Arabidopsis
National Science Foundation—$200,000
(B. Nikolau, biochemistry, biophysics and molecular biology)

Regulation of Starch Synthesis in Maize Kernels: Function of Starch Synthase III
Department of Energy—$120,000
(M. James, biochemistry, biophysics and molecular biology)

Building Consensus Genetic Maps for Maize and Wheat
Binational Agricultural Research and Development Fund (BARD)—$115,000
(P. Schnable, agronomy)

PlantGDB – Plant Genome Database and Analysis Tools
National Science Foundation—$68,537
(V. Brendel, genetics, development and cell biology)

Iowa Botanical Supplements Research Center
National Institutes of Health—$1,301,731
(D. Birt, food science and human nutrition)

Enzyme-Assisted Aqueous Processing of Soybeans
USDA—$780,966
(L. Johnson, food science and human nutrition)

Comparative Evolutionary Genomics of Cotton
National Science Foundation—$686,817
(J. Wendel, ecology, evolution and organismal biology)

VCA: A Two Component AC/DS Platform for Reverse and Forward Genetic Analysis in Maize
National Science Foundation—$392,967
(E. Vollbrecht, genetics, development and cell biology)

PLEXdb: Plant Expression Database
National Science Foundation—$354,418
(J. Dickerson, electrical and computer engineering)

Enzymatic Cyclization to Labdanes and Related Diterpenoid Natural Products
National Institutes of Health—$280,709
(R. Peters, biochemistry, biophysics and molecular biology)

Genomics of Rice Susceptibility to Bacterial Diseases
National Science Foundation—$232,007
(A. Bogdanove, plant pathology)

SoyMap: An Integrated Map of Soybean for Resolution and Dissection of Multiple Genome Duplication Events
National Science Foundation—$189,830
(R. Shoemaker, agronomy)

Breeding General-Use and Specialty Soybeans for Iowa
Iowa Soybean Association—$162,240
(W. Fehr, agronomy)

Enabling Graduate Learning in Risk Analysis with Emphasis on Food, Agriculture and Veterinary Medicine
USDA—$146,813
(J. Wolt, agronomy)

Characterization of the Soybean Rust Infection Process in Susceptible and Resistant Soybean Interactions
Iowa Soybean Association—$95,074
(S. Whitham, plant pathology)

Relational Legume Genome Database: The Breeder's Toolbox
USDA, ARS—$85,000
(V. Brendel, genetics, development and cell biology)

Arabidopsis Nonhost Resistance for Creating Novel Soybean Germplasms with Durable and Broad-Spectrum Phytophthora Resistance
The Consortium for Plant Biotechnology Research, Inc.—$46,110
(M. Bhattacharyya, agronomy)

Nonhost Resistance for Engineering Disease Resistance in Soybean
Iowa Soybean Association—$43,000
(M. Bhattacharyya, agronomy)

Engineering Carbohydrate Polymers for Value-Added Products from Agricultural Feedstocks
Petroleum Research Fund, American Chemical Society—$40,000
(N. Pohl, chemistry)

Food Chain Economic Analysis
USDA, CSREES—$384,475
(C. Hurburgh, agricultural and biosystems engineering)

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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