Iowa State University
Plant Sciences Institute UPDATE
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Steven Briggs (light blue/silver suit, one o'clock, outer ring)—satisfying his detoured aerial ambitions with an active skydiving hobby—earned a fifth place finish at last year's national championships in eight-way formation competition in Skydive, Arizona.

Jumping into the fray

Scientifically skilled and savvy, Steven Briggs seemingly does it all. As chair of the Plant Sciences Institute board, he brings a long history of balancing academic and corporate interests to this leadership role.

Briggs is professor of cell and developmental biology at the University of California, San Diego, and a recently elected member of the National Academy of Sciences.

Additionally, the Vermont native, who grew up planning to pilot fighter jets with ambitions to become an astronaut, is now part of a team of biotech entrepreneurs brewing jet fuel in La Jolla, California.

Briggs holds the role of scientific collaborator to the microalgal-based bioenergy company, Sapphire Energy, a startup primarily funded by the Wellcome Trust and Bill Gates' investment company, Cascade Investment.

Briggs' corporate scientific career began in Iowa at Pioneer Hi-Bred International. A move to San Diego

CONTINUED ON PAGE 2

Green slime starts to shine

Natural photosynthetic systems that use solar energy to capture carbon are ripe for engineering innovation. One group holding promise for generating renewable biofuels and chemicals are microalgae, organisms Martin Spalding, professor and chair of the Department of Genetics, Development and Cell Biology, has been studying for over 30 years.

Primarily focused on the model microalga, *Chlamydomonas reinhardtii*, Spalding is working to overcome metabolic obstacles to encourage natural oil production in these single-celled photosynthetic organisms.

"*Chlamydomonas reinhardtii* is the only microalga with a robust genetic engineering base, and the only microalga we can easily manipulate genetically to combine traits," explains Spalding. "It is highly malleable and we can transform all three of its genomes—nuclear, chloroplast and mitochondrial."

The organism stores its carbon as oil more readily when deprived of certain nutrients but preferentially stores excess carbon in the form of starch. Starch is its energy source during dark periods. But when microalgae are grown in constant light, Spalding explains, they don't need starch to live.

So Spalding and colleagues Larry Halverson, assistant professor in the Department of Plant Pathology, and Basil Nikolau, Francis M. Craig

CONTINUED ON PAGE 2

Sense of direction

In the face of changing priorities, we sometimes lose our sense of direction. We built a biofuels industry in Iowa, because the nation wanted to free itself from dependence on foreign

oil. A few years ago, that made sense. Oil prices were outrageously high, corn and soybeans were relatively cheap—ethanol looked like a good deal. In the interim that equation has turned on its head and biofuels no longer have the caché they had back then. Instead the industry has been criticized for falling short of new priorities.

Science magazine, one of the most respected scientific journals, headlined a Newsfocus article (May 1, 2009) with "Corn-based ethanol flunks key test." Their issues concerned the California Air Resources Board adoption of a low-carbon fuels standard that included indirect land use change in the policy.

Another study published in *Science* (Chiu, et al. 2009) reported that corn grown for biofuels consumes, on average, 1,000 gallons of (irrigated) water for every gallon of ethanol. Yet another study (Campbell, et al. 2009) finds that it is more efficient to burn biomass directly to make electricity than it is to convert it to biofuels.

Fortunately, the Obama administration has taken strong steps to support the biofuels industry and to address these issues by establishing a Biofuels Interagency Working Group with the goal to "develop a comprehensive approach to accelerating the investment in and production of American biofuels and reducing our dependence on fossil fuels."

What should come out of the working group and from the administration are steps to support research addressing these new priorities rather than abandoning our sense of direction.

Stephen Howell
Director

Jumping into the fray/CONTINUED

to head the Novartis Agricultural Research Institute soon put Briggs in the position of brokering the controversy-provoking $25 million agricultural biotechnologies deal in 1998 between the University of California, Berkeley, and the Swiss life sciences giant Novartis.

Analyses of the deal continue to refine guidelines for future partnerships between corporations and land-grant universities. The novel deal also helped pave the way for UC Berkeley's $500 million collaboration with oil giant BP, creating the Energy Biosciences Institute in 2007.

The Novartis Agricultural Research Institute eventually morphed into the Torrey Mesa Research Institute (TMRI)—a name change followed by dissolution when Novartis spun off its agricultural division creating Syngenta.

While heading the Torrey Mesa Research Institute, Briggs also led the team that produced the first draft sequence of the rice genome. Although it was an historic accomplishment, it brought about a research shift in his career.

"I was a genomics guy," says Briggs. "I decided to get out of the nucleus and start dealing with proteins."

When not tinkering with microalgae, Briggs' main research focus is on data management tool development for tracking genome-wide molecular signaling pathways.

"In the past, whole-cell signaling was all inferred because the tools didn't exist to study the transfer of atoms between proteins," explains Briggs.

Creating data is no longer a holdup with today's next generation sequencing capabilities. The new bottleneck is data management—making sense of all the information. Automated software-driven systems can be used to identify new gene sequences, but these systems "are only accurate for about 70 percent of the genes," says Briggs.

Instead, Briggs relies on high-throughput proteogenomics methods with improved sample preparation and mass spectrometry techniques to resolve the rest.

Green slime starts to shine/CONTINUED

Professor in the Department of Biophysics, Biochemistry and Molecular Biology, selected a starchless mutant for study—one that cannot store carbon in starch, because it lacks a necessary enzyme.

They will compare the essential genes and metabolites of this mutant to the wild type, setting their sights upon identifying vital modifications in this metabolic pathway that will optimize oil production. As this mutant is also only a moderate oil producer, detecting even small increments in oil production advances should be straightforward.

Additionally, the team will introduce prospected genes from other organisms into the mutant, such as plants or other microalgae, whose biochemical products might shepherd carbon through the lipid biosynthetic pathway.

"We will be pushing from the beginning of the pathway and pulling from the end

to improve the amount of oil produced," says Spalding.

Initial support for this project is being provided by the institute's Innovative Grants Program.

Welcome Sharron Quisenberry

Sharron Quisenberry has joined Iowa State as the new vice president for research and economic development (VPRED). Originally from northern Missouri, the former dean of the College of Agriculture and Life Sciences at Virginia Tech, is thrilled to be back in the landscape of her youth.

Quisenberry, who maintained an active research program until she accepted the role of dean in 2003 when her new responsibilities made it impossible to meet with her students and to keep up with current literature, is enthusiastic about her new position for many reasons.

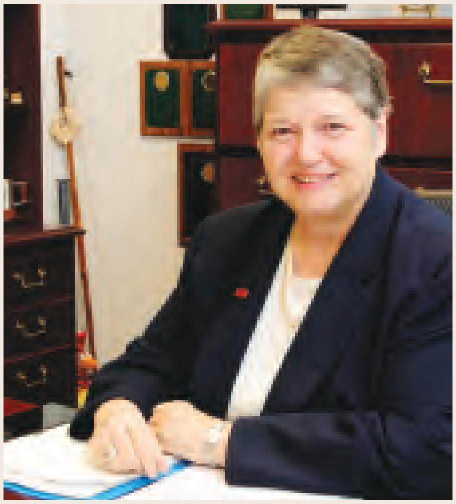
One is her exposure to "the very broad view of the technologies, the tools and the great research people are doing," says Quisenberry. "Within the past decade, research capabilities have progressed so that we now have the ability to solve problems, working across disciplines."

Quisenberry's immediate goal is to help the faculty she represents increase the number of research grants and contracts awarded.

"I'm here to facilitate, identify the road blocks and remove them," says Quisenberry, "to make it as easy as possible for our faculty to succeed. I never forget where I came from as a faulty member, many of whom on this campus are outstanding and unique and I always consider how I would feel in their position—you never want to forget that."

Quisenberry takes the helm at a fiscally tough time with the recent economic downturn diminishing state contributions. Nevertheless, Quisenberry expects to significantly increase faculty-earned research dollars over the next three to five years.

The institute is a responsibility of the VPRED and will be reviewed beginning this year as will all the university's many centers and institutes.



Resources should not be looked upon as entitlements, but rather incentives to build capabilities within the university community, explains Quisenberry. "If resources are used effectively and leveraged across units, it is a win-win for everyone."

Molecular mapping of plant metabolites and their dynamics

Efforts to exploit plant systems for the production of small metabolites, valued in biofuels and chemical industries, often depend on detecting minute differences between the metabolic makeups of different organisms.

"Chemical composition changes are not uniform throughout an organism," says Young-Jin Lee, assistant professor in the Department of Chemistry. Lee is developing mass spectrometry imaging technology to identify, localize and quantify key metabolites with spatial resolution at a single cell level.

For proof of concept, Lee, who joined Iowa State last year following a stint at the University of California, Davis, Genome Center, used a Thermo Finnigan vMALDI LTQ Linear Ion Trap to positively identify and spatially resolve two different types of epicuticular wax metabolites—caffeate and coumarate—on the surface of micron-size *Arabidopsis* root hairs, the first mass spectrometric imaging ever achieved on such tiny plant structures.

In brief, Lee dried plant samples on a stainless steel plate and coated them with a graphite or silver-based ionizing matrix.

Using his high-resolution mass spectrometer to perform localized sampling over narrow areas, Lee acquired mass spectra at hundreds of x-y positions allowing him to generate a two-dimensional chemical image of the plant structure for each molecular compound.

"Current metabolomics technology is not position sensitive," explains Lee. "Now we can see how these changes are distributed—localize the destination of metabolites on a single cell level."

Lee is a physical chemist by training and sees this interdisciplinary area of bioanalytical mass spectrometry as an amazing opportunity.

"We are bioanalytical chemists, folks from the physical science sector, working between chemistry and biology, developing and inventing tools that improve biology—enabling us to discover a whole new world," says Lee. "Mass spectrometry imaging is like a new microscope where we cannot only see but also identify the chemical structure of specimens."

Currently, Lee is attempting to improve his identification accuracies by employing a new hybrid mass spectrometer that has high-mass accuracy and performs direct chemical composition analysis on the sample target.

He is also working on several pioneering projects, including the use of cross-linking agents and mass spectrometry, to study the three-dimensional structure of proteins or protein complexes, and a high-throughput mass spectrometric assay to characterize hundreds of bio-oil compounds or complex algae products relevant to biofuels production.

Recent research grants

The following 23 new grants totaling $10.3 million were awarded recently to plant science researchers at Iowa State.

Protein Polymer Product Development
Soy Works Corporation—$85,864
(D. Grewell, agricultural and biosystems engineering)

Aspects of Integrated Management for Viruses and Phomopsis Infection in Soybean
Iowa Soybean Association—$59,059
(G. Munkvold, plant pathology)

Plant Resistance to Aphids
Dow AgroSciences, LLC—$53,893
(B. Bonning, entomology)

Effect of Feeding Corn Genetically Modified to Contain Amylase on Body Weight Gain, Feed Intake, and Feed Efficiency of Feedlot
Syngenta Corporation—$36,634
(D. Beitz, animal science)

GEPR: Transcription Profiling and Functional Analyses of Bacterial Disease Susceptibility Pathways of Rice
National Science Foundation—$589,558
(A. Bogdanove, plant pathology)

Rice as a Model System for Elucidating Diterpenoid Metabolism in Cereal Crop Plants
USDA, CSREES—$325,192
(R. Peters, biochemistry, biophysics and molecular biology)

Application of New Genetic Resources to the Improved Control of Soybean Sudden Death Syndrome
United Soybean Board—$295,870
(S. Cianzio, agronomy)

Risk and Benefit Analysis for Genetically Modified Agricultural Products
USDA, APHIS—$247,198
(M. Misra, agricultural and biosystems engineering)

Genetic Mechanisms Regulating Inflorescence Architecture in Maize and Related Cereals
National Science Foundation—$239,786
(E. Vollbrecht, genetics, development and cell biology)

High-Accuracy Protein Models Derived from Lower Resolution Data
National Institutes of Health—$231,555
(A. Kloczkowski, biochemistry, biophysics and molecular biology)

Soybean Transformation
Dow Agrosciences, LLC—$90,990
(K. Wang, agronomy)

PIRE: Molecular Engineering for Conversion of Biomass-Derived Reactants to Fuels, Chemicals and Materials
National Science Foundation—$64,000
(B. Shanks, chemical and biological engineering)

Training Maize Breeders for Sustainable Bioenergy Maize Production
USDA, CSREES—$499,966
(T. Lübbersted, agronomy)

Genomic Analyses of Shoot Meristem Function in Maize
National Science Foundation—$358,619
(P. Schnable, agronomy)

Coarse-Grained Models of Proteins
National Institutes of Health—$315,171
(R. Jernigan, biochemistry, biophysics and molecular biology)

The Dose-Response Effects of the Amount of Fat in Salad Dressing on the Bioavailability of Carotenoids, Phylloquinone, and Tocopherols in Salad Vegetables
Unilever Research and Development—$150,772
(W. White, food science and human nutrition)

The Effect of Soy Protein on Blood Pressure in Prehypertensive/Stage 1 Hypertensive Premenopausal Women
Iowa Soybean Association—$120,000
(W. Franke, kinesiology)

Development and Commercialization of Soy/Corn/Linseed Oil Bioplastics
Consortium for Plant Biotechnology Research, Inc.—$54,000
(R. Larock, chemistry)

ERC 2: Center for Biorenewable Chemicals
National Science Foundation—$3,250,000
(B. Shanks, chemical and biological engineering)

Biofuels Research Program
ConocoPhillips Company—$2,546,541
(R. Brown, mechanical engineering)

Aphid Luteovirus Interaction: Aphid Receptors, Luteovirus Receptor-Binding Domains and Blocking Luteovirus Transmission
USDA, CSREES—$400,000
(B. Bonning, entomology)

Biofuels Research Program
Archer Daniels Midland—$212,077
(R. Brown, mechanical engineering)

Enzyme Digestibility of Starch in Animal Feed
Nugenplasm Company—$98,473
(J-L Jane, food science and human nutrition)

Plant Sciences Institute UPDATE

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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 and Life Sciences, 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.

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