Plant Sciences Institute
Iowa State University
1060 Roy J. Carver Co-Laboratory
Ames, Iowa 50011-3650
Phone: 515 294-5255
Web: www.plantsciences.iastate.edu

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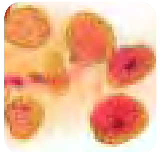
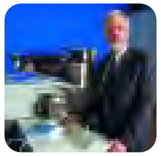
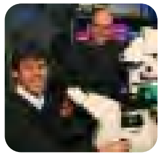
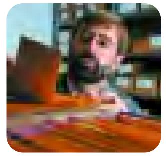


IOWA STATE UNIVERSITY
Plant Sciences Institute



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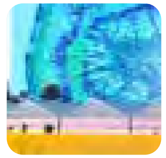
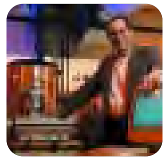


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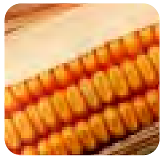


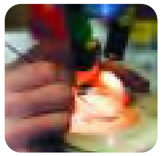






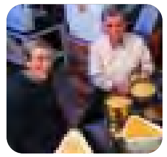

"Excellence in plant sciences is critical to Iowa State University. The Roy J. Carver Co-Laboratory will have a significant impact on our ability to make important discoveries and to turn the discoveries into new economic development opportunities for Iowa. It's where the next generation of biotechnology will be born."

—GREGORY L. GEOFFROY, President, Iowa State University

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OPENING DOORS OF OPPORTUNITY

Our report this year highlights how the Plant Sciences Institute is creating opportunities for the future of Iowa in agricultural biotechnology.

Biotechnology has the best prospect to add value to Iowa agriculture and to enrich Iowa's economy. We believe that the Institute can open doors—enabling Iowans to become world leaders in agricultural biotechnology.

The new Roy J. Carver Co-Laboratory is the centerpiece of the institute's biotechnology efforts and is featured in this report. The Co-Laboratory is a unique facility to encourage scientists in the public and private sector to work together. The Innovations Development Facility, a new organization to promote economic development in the Co-Laboratory, will enable interested Iowa State faculty, staff, and students to commercialize their research—and for enterprising scientists to start new companies in the Co-Laboratory business incubators.

The Roy J. Carver Co-Laboratory will be an intense and scientifically exciting place—home to some of the research stars among the Iowa State biotechnology faculty. The Co-Laboratory will also house state-of-the-art facilities for genomics and proteomics research. These facilities offer cutting-edge technologies to enable Iowa State scientists to improve crops by examining the expression of thousands of plant genes and proteins.

The institute is coordinating with other efforts in the state enabling Iowans to become leaders in the production of high-valued proteins and biomass from plant systems. Work conducted in the Center for Crops Utilization Research is directed toward developing technologies for the production and processing of biopharmaceuticals from plants. This activity will contribute to the development of the Iowa Biologics Facility, which is taking shape in the Iowa State University Research Park—a facility for the purification and production of high-valued proteins from bioengineered plants.

Institute scientists want to keep the doors of opportunity open for the safe and proper use of biotechnology by developing public confidence in the containment of bioengineered crops. To this end, institute scientists associated with the Biosafety Institute for Genetically Modified Agricultural Products (BIGMAP) are designing a risk assessment tool to help public policy makers and others safely produce genetically modified agricultural products.

In coordination with Office of Biorenewables Programs, institute scientists are creating opportunities by improving plant biomass production and developing biorenewable products, such as biodegradable plastics and natural fibers. Other institute scientists are integrating new biotechnological techniques into traditional plant breeding programs to address nutritional quality issues in our food and feed supplies. Of special note in this regard, is the effort of institute scientists to develop biofortified crops to help in alleviating the devastating effects of vitamin and mineral deficiencies in the developing world.

The institute has also created opportunities for crop scientists worldwide by developing and curating genome databases for the major crops of Iowa—corn and soybeans. Genomics has become an intense informational science, and scientists around the globe contact Iowa State every day through the Web for information about corn and soybean research.

As you will see in the following pages, these institute activities add up to greater opportunities for us all—and greater riches for agriculture and industry in our state.

STEPHEN H. HOWELL, Director

After the dedication ceremony of the Roy J. Carver Co-Laboratory on October 18, 2003 (left to right): Dan Saftig, president, Iowa State University Foundation; Troy K. Ross, executive administrator, Roy J. Carver Charitable Trust; Gregory L. Geoffroy, president, Iowa State University; Stephen H. Howell, director, Plant Sciences Institute; Owen Newlin, Board of Regents, State of Iowa; Lynn Sasmazer, program director, Roy J. Carver Charitable Trust.

NEW TECHNOLOGIES SPROUT FROM THE ROY J. CARVER CO-LABORATORY

Roy J. Carver Co-Laboratory occupants will be some of the first to use new technologies developed within the Plant Sciences Institute's academic environment. In addition, the scientists who develop these new technologies may be right next door.

The Roy J. Carver Co-Laboratory building, completed and dedicated this year, is a revolutionary new research space where want-to-be and real corporate scientists can work shoulder to shoulder with academic researchers. The mix is intended to promote collaborative research, create opportunities for sharing technologies and strategies, and provide faculty, staff, and students with insights to the business world.

Award-winning innovator Edward Yeung, distinguished professor and Robert Allen Wright Chair, is one academic scientist Roy J. Carver Co-Laboratory occupants will find close at hand.

Yeung's innovative applications of micro-scale chemical analysis, laser surface interactions, data management, nonlinear spectroscopy, laser-based detectors for liquid chromatography, capillary electrophoresis, single-cell and single-molecule analysis, high-speed DNA sequencing, and data treatment procedures in chemical measurements continue to create opportunities for researchers from many different biological disciplines to design novel experiments that open doors to new discoveries.

Additionally, Yeung holds 21 patents for technologies he has developed. He has received numerous national awards for his discoveries, including four R&D 100 Awards, considered by many as the "Oscars" of applied science.

Yeung's laboratory has just developed instrumentation that can be used to make a genetic fingerprint of a single cell. Instead of hours or days, the fingerprint can now be in researchers' hands within minutes. The sensitivity this system offers is a remarkable improvement over previously used methods.

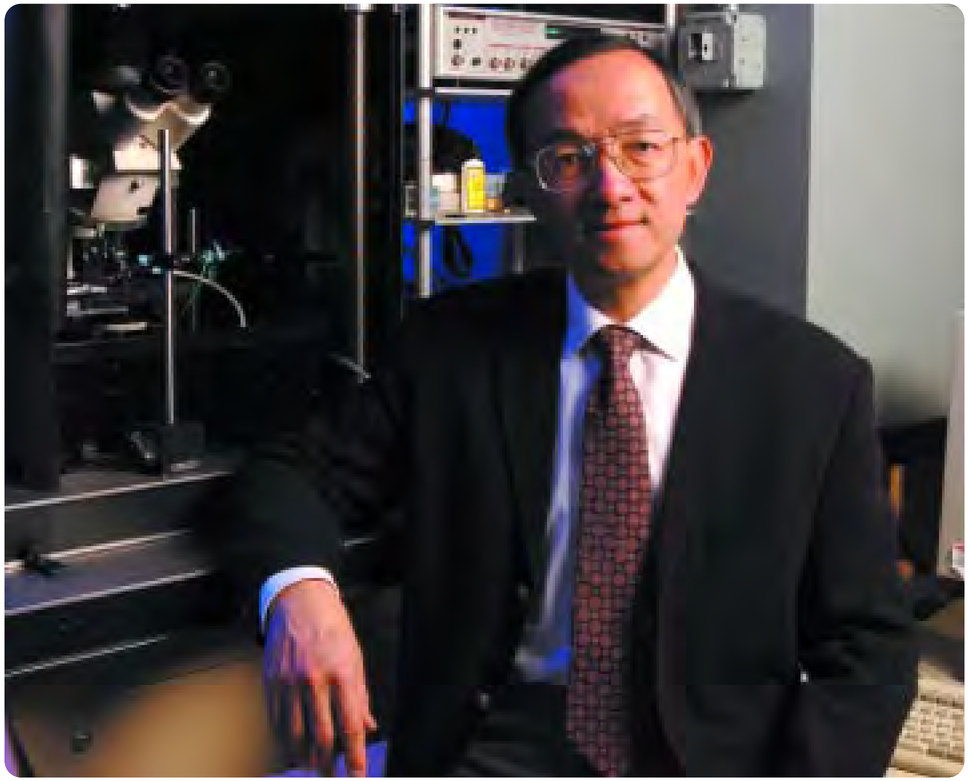
A new generation of CCD camera, "a sophisticated form of a camcorder," explains Yeung, combined with our new design of lasers and microscope optics, allows us to look at all sizes of DNA in a cell.

For example, if researchers were trying to find an elusive gene involved in the complex chemical defense system of leaf cells, Yeung's fingerprinting technique might provide the means.

Researchers could isolate a tiny hair cell from the leaf being studied, called a trichome. Using a special dish laid out with rows of tiny wells and a specially modified microscope, the trichome would undergo all the identifying chemical reactions while resting in the well, and the fingerprint would be revealed within about ten minutes.

Initially designed for use with mammalian cells, Yeung is adapting his new technology for use with plant cells. The comparatively thick wall surrounding plant cells is more difficult to pierce than the soft mammalian cell membrane, he notes.

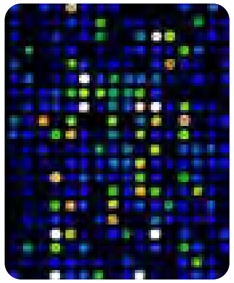
Yeung is preparing to reveal a new system he has designed that identifies and quantifies small amounts of protein. His system will separate hundreds to thousands of proteins from the soup of proteins in a cell. Researchers using the new technology will have an opportunity to identify, isolate, and study important proteins that have previously eluded them.



Edward Yeung combines technology with basic scientific principles to create a plethora of useful tools.

CORN GENES COME TOGETHER IN THE NEW ROY J. CARVER CO-LABORATORY

Corn researchers can now look at the expression of thousands of genes at the same time with Iowa State University's new corn chip. Developed this year, the corn chip is a tiny glass slide with segments from 12.5 thousand corn genes attached.



Developed for use in the state-of-the-art microarray facility that is housed in the Pioneer Hi-Bred International Genomics Laboratory, the corn chip allows researchers to ask which genes are being expressed, explains Patrick Schnable, director of the Center for Plant Genomics and professor of agronomy and genetics, development and cell biology.

The Pioneer Hi-Bred International Genomics Laboratory, which is supported by the Plant Sciences Institute and by a USDA training grant, under the direction of Susan Carpenter and Chris Tuggle, and by the Iowa State University Office of Biotechnology, is part of the new Roy J. Carver Co-Laboratory.

Already the Genomics Laboratory has supported two Iowa companies testing their pilot technologies using the microarray technology. Iowa State undergraduate students will also be making use of the microarray this year in a joint program with Truman State University in Missouri.

A powerful new technique in the Genomics Laboratory called laser capture microdissection has enabled Iowa State researchers to isolate individual cells from a particular type of plant tissue, such as roots or leaves.

Schnable and Daniel Nettleton, an associate professor of statistics, along with researchers at the University of Georgia and Cold Spring Harbor Laboratory in New York, will study the genes expressed in the shoot apical meristem—the tiny dome of cells that gives rise during plant development to the entire above-ground part of the plant.

Hundreds of genes are turned on at different times in the many different types of cells that make up the shoot apical meristem. Iowa State students working with these researchers will learn the finer points of RNA extraction from cells in different sections of the corn plant's meristem, and amplifying it to amounts needed for microarray analysis. The results generated will help define specific regions in the meristem where morphology and gene expression differ.

Truman State students will be finding out what is known about these genes. Their efforts will help hone their skills at searching the literature, reading, and thinking, and ripen their integrating abilities by using the public database Medline.

Ultimately, these findings may help scientists learn how to encourage plants to grow in different ways, for example, making it possible to increase plant densities in production fields.

Patrick Schnable (left) and Daniel Nettleton explore gene expression in the shoot apical meristem to reveal the intricacies of corn plant development.

ESTABLISHED COMPANIES NURTURE NEW ONES IN THE INNOVATIONS DEVELOPMENT FACILITY

New opportunities for commercializing research or developing businesses in plant biotechnology will be generated within the new Innovations Development Facility established in the Roy J. Carver Co-Laboratory.

The Innovations Development Facility includes an incubator facility for start-up companies and a 3P Program (Public-Private Partnership Program).

The 3P Program is designed to promote interaction and exchange between corporate and Iowa State University scientists housed within the new building. The business incubator provides a transitional setting to encourage interested Iowa State faculty, staff, and students to try their hand at business in a university research environment.

“Our goal is to get researchers from established companies to mentor people just starting out,” explains Cheryl Kamman, the recently named director for the facility.

The hope is that the mix of seasoned company scientists and entrepreneurial faculty will foster good collaborations with lots of discussions, instead of the more typical confidential nonsharing sort of atmosphere many experience when dealing with corporations.

The Innovations Development Facility offers wet laboratory spaces, office spaces, and common equipment rooms filled with equipment such as centrifuges, incubators, and microscopes, which are essential tools for researchers but expensive to buy and maintain for an individual group just getting established.

Also provided will be access to copy machines, receptionist support, phone and Internet connections, and conference rooms, as well as various facility and safety services from Iowa State University.

Business resources are also available to help the incubator ventures. The Small Business Development Center housed at the Gerdin Business Building, as well as the Iowa State Pappajohn Center for Entrepreneurship can help start-ups craft business plans, research proposals and technology transfer requests. Tenants will also work with the Iowa State University Office of Intellectual Property and Technology Transfer to help them handle licensing and patenting issues.

The hope is that this facility will create new opportunities for the private sector to work in the university environment and encourage the transfer of more university research in the area of plant sciences into the private sector so that society can benefit more directly from these scientific discoveries.

Academics and industry scientists engage on a new playing field under Cheryl Kamman’s direction.

PROCESSING ENGINEERS FOCUS ON IOWA CROPS FOR VALUABLE BIOPHARMACEUTICALS

Iowa State University researchers in the Center for Crops Utilization Research are working to simplify the extraction and purification of biopharmaceuticals from plants. Their efforts will result in the building of a new set of technologies that will support the protein purification facility planned for the Iowa State University Research Park.

The research focuses on using corn as a host to produce recombinant proteins to create new drugs, health supplements, and industrial enzymes. Strategies are to be worked out that best fit the different grain fractions, giving the highest quality, purity, and yield of targeted proteins.

"Which plant tissue these proteins are expressed in can greatly simplify recovery and purification," explains Larry Johnson, director for the center and a professor of food science and human nutrition.

Two farmers in northern Iowa are growing a line of transgenic corn developed by Meristem Therapeutics, in Clermont Ferrand, France. The corn is engineered to produce the enzyme lipase that is useful in treating patients with cystic fibrosis.

Johnson and colleague Charles Glatz, a professor and chair of chemical engineering, are working on ways to dry mill the lipase-producing corn. Using different grinders and sieving devices, Johnson is working to develop low-cost, low-tech, portable dry extraction approaches that can be used on the back of a truck or trailer in the field.

Once the lipase-containing corn is milled and separated into fractions rich in lipase, Glatz completes the extraction and purification of the lipase and tests the integrity of the biopharmaceutical protein using chromatography.

Fractionating the transgenic seed corn in the field decreases the risk of cross contamination with commodity corn, according to Johnson, particularly if the seed is rendered nonviable in the field.

Johnson is not a fan of wet-milling extraction methods because typically they rely on chemicals and temperatures that are not friendly to therapeutic proteins. Additionally, they can be more expensive, he says.

Whether it is endosperm, germ, or pericarp, the tissue engineered to express the desired protein determines how easily it can be extracted and how expensive extraction might be, explains Johnson.

For example, if the desired protein is made in the germ, a part of the corn kernel ripe with plant protein, purifying one protein away from all the others may be more difficult and more expensive. But, it may be where corn produces certain proteins best.

Expression and extraction conditions might differ depending on the particular protein of interest. Plant Sciences Institute researchers will build on Glatz and Johnson's efforts by further developing manufacturing techniques. These will be used in the new biologics and protein purification facility for the extraction of valuable proteins from new types of corn and other crops.

Charles Glatz (left) and Larry Johnson try out tools for the extraction of future biopharmaceuticals.

BIORENEWABLE EXPERTISE BURGEONS AT IOWA STATE UNIVERSITY UNDER THE BIOECONOMY INITIATIVE

A new graduate program at Iowa State University will train scientists/engineers needed for a sustainable future. The first Biorenewable Resources and Technology graduate program in the United States offers advanced studies in the use of plant and crop-based resources for the production of biobased products.

Making chemicals, power, plastics, fuels and materials from plants is widely believed to have the potential to improve environmental quality by reducing pollutant emissions associated with fossil fuel use, like sulfur, heavy metals, and greenhouse gasses. They also have the potential to liberate the United States from its foreign oil dependence.

To convert crops and plants into these biobased products requires collaborations among many different disciplines, including molecular biology, agriculture, chemistry, and engineering. While many experts exist in these disciplines, few have been unified in an academic setting to prepare students following graduation to take positions in the multidisciplinary biobased industry.

Students are developing a variety of skills by taking a systems perspective rather than focusing on a specialty, working on teams, communicating with diverse groups of people, and grasping the culture of market-driven companies. Additionally, students will accumulate knowledge outside traditional academic disciplines.

Faculty associated with the Biorenewable Resources and Technology graduate program conduct innovative research programs of their own in the areas of plant science, production, processing, and utilization, as part of the Bioeconomy Initiative at Iowa State.

Iowa State has recently won three contracts to develop specific biobased products from biorenewable resources.

Robert Brown, director of Iowa State's office of Biorenewables Programs and a professor of mechanical engineering and chemical engineering, is leading a team to convert distillers' dried grains into biobased plastics.

A second team headed by George Krauss, a professor of chemistry, will study new technologies for making an environmentally friendly diesel fuel and industrial solvent from soybeans.

Eve Wurtele, a professor of genetics, development and cell biology, along with Basil Nikolau, director of the Center for Designer Crops and professor of biochemistry, lead the third team. They will be developing genetically engineered crops to make proteins that can be processed into a family of biodegradable polymers and energy.

Recent expertise added to the program comes from new faculty member Robert Anex, an associate professor of agricultural and biosystems engineering and a research associate of the Center for Sustainable Environmental Technologies.

Anex's research employs a key tool called life cycle assessment—a technique for assessing the overall environmental burden and resource use of a product and the system used for manufacturing it.

Evaluating biobased products relative to their petrochemically derived equivalents is essential, explains Anex, so researchers and industry officials can be certain the new technologies offer the improvements they promise.

Robert Brown leads a biorenewables team.

MOLECULAR BIOLOGY AND TRADITIONAL PLANT BREEDING ADVANCE TOGETHER ON COMMON GROUND

Marrying molecular biology breakthroughs with traditional plant breeding methods promises new opportunities to develop more robust, more nutritious, and more affordable crops that can be farmed around the world in a sustainable fashion.

Iowa State University researchers associated with the Raymond F. Baker Center for Plant Breeding are confronting the major research and outreach challenges that stand in the way of achieving this objective.

"Coping with the biocomplexity of plant systems along with corporate ownership of specific genes are central issues we are working to address," says Kendall Lamkey, director of the Raymond F. Baker Center for Plant Breeding and a professor of agronomy.

More dialogue between plant breeders and the rest of the plant science community is acutely needed, explains Lamkey, because how you go about genetically improving plants from a plant breeder's perspective is a very complex problem.

Molecular biology properly integrated with traditional plant breeding techniques creates a tremendous opportunity to remedy the nutritional quality issues of current cereal crops. But this information needs to be made available to farmers and the general public in a useful and intelligible manner.

To this end, Lamkey is heading up a plant breeding outreach project in Iowa. His team is physically getting out into the cornfields with farmers and educating them about what sorts of traits plant breeders select for. This creates an opportunity for farmers who want to develop their own corn, to learn from Iowa State breeding experts how to go from cultivars to varieties to their own germplasm.

To address these issues on a more global level, the Raymond F. Baker Center for Plant Breeding co-hosted a symposium this year that was attended by plant breeding experts from around the world. Held in Mexico City, the symposium created an opportunity for open dialogue between industry scientists and traditional plant breeders.

The resulting discussions illustrated the complexity of food problems, but opened the door for industry scientists and traditional breeders to initiate collaborations that will offer innovative and practical solutions. It also served as a forum for breeders to examine ways to include the breakthroughs in molecular biology with their traditional plant breeding programs.

Kendall Lamkey prepares to head out into the fields with Iowa farmers.

Three hundred participants came from 63 different countries; half were from the third world, primarily Africa, where the stresses and demands involving crops make improvements particularly challenging. The symposium was co-hosted by CIMMYT, the Iowa State University College of Agriculture, Pioneer Hi-Bred International, and the Monsanto Company.

The outreach efforts being generated by the Raymond F. Baker Center are helping to equip farmers with an abundance of scientific information to help them make decisions for themselves about their own crop needs.

Lamkey is working with Iowa farmers to define what traits they will need from their crops six to ten years down the road. Additional efforts are underway to make germplasm affordable, publicly available, and designed for sustainable farming practices.

BIOINFORMATICISTS MAKE ACCESS EASY TO THE INNER WORKINGS OF CORN AND SOYBEANS

The wealth of information being generated by the prolific corn and soybean research community is readily accessible to any researcher worldwide thanks to the efforts of two Iowa State University research laboratories.

"It's one-stop shopping," says molecular biologist David Grant, curator for the USDA soybean genetics and genomics database known as SoyBase.

SoyBase, maintained by the laboratory of USDA collaborator and professor of agronomy Randy Shoemaker, and a similar database, called MaizeGDB, that is maintained by the laboratory of Bergdahl Professor of Bioinformatics Volker Brendel, harnesses the volume of information flowing directly from the use of high throughput sources.

This wealth of information creates a challenge to database centers. Databases like SoyBase were originally developed about 12 years ago using ACeDB, a database program written by molecular biologists working on the worm *C. elegans.* ACeDB was a hybrid between what computer programmers call an object database and a relational database.

"It works like a charm up to a point," says Grant "but with the recent increases in genomic databases that are based on a relational model, it has become clear that converting SoyBase to a similar structure would increase our ability to combine soybean data with those from other species for subsequent analysis."

As the data sets get larger and more numerous, so too do the possible questions researchers want to ask. Shoemaker's lab is redesigning the structure of SoyBase to proactively address these needs, a behind-the-scenes effort that is expected to take about three years.

The end result will allow users to easily find everything they wanted to know about soybeans no matter how they enter the database. In other words, if a researcher enters the database by looking at a genetic map, they can travel on and explore with ease everything known about particular pathogens, proteins, or metabolic pathways.

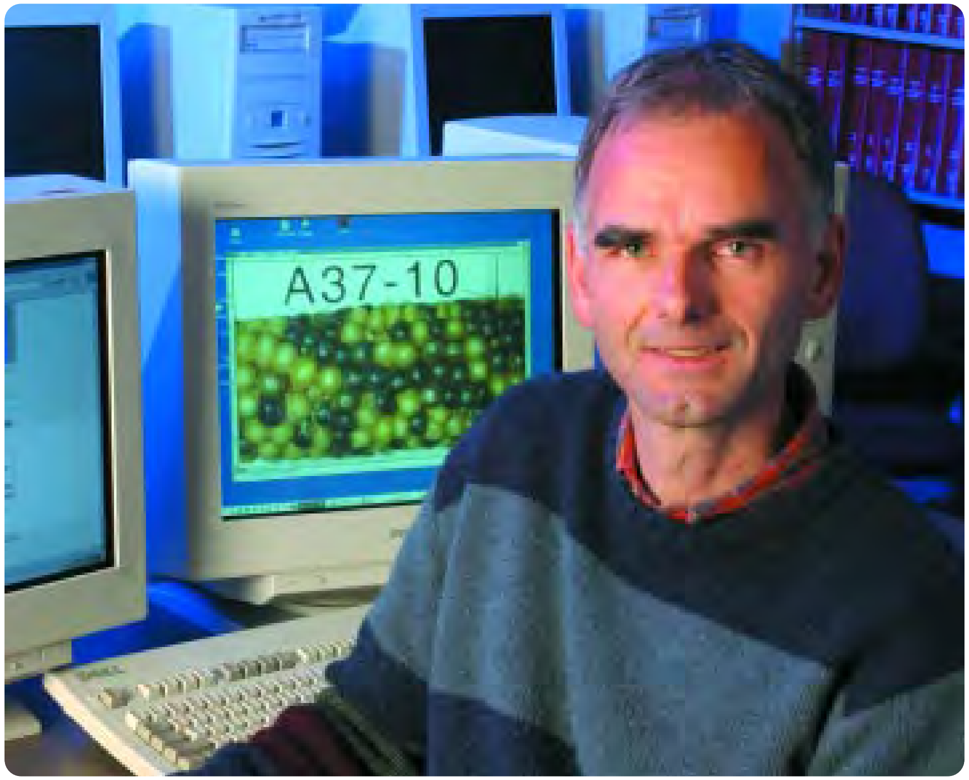
Because the data will be well linked to other databases, cross-species comparisons will be easily accomplished.

"The underlying software will be different," says Grant "but users shouldn't notice any difference except that it will be even more useful than before."

MaizeGDB managed by Brendel's laboratory has already set up a relational database that can accommodate many more users at one time. Still, someone must enter the new data being continually generated.

In an effort to streamline the sharing of new scientific information by eliminating third-party data entry, Brendel has designed what he calls an "editorial board." Scientists will get an account that allows them to directly add their newly published discoveries to the database. A scientist curator will look it over to ensure accuracy, and if approved, it will enter the public domain.

By making each researcher responsible for their own data, the people who are most interested in the data—those generating it—become empowered, explains Brendel. And this creates an opportunity for database users to make more connections from the added information.



Volker Brendel is making sure everything you ever wanted to know about corn is at your fingertips.

NEW BUSINESSES BLOSSOM AT IOWA STATE UNIVERSITY'S RESEARCH PARK

The Iowa State University Research Park is home to some 50 companies operating within its eight buildings. Some are established companies and others are just getting their feet wet within the sheltered confines of an incubator setting.

The park creates an opportunity for new businesses to establish themselves in an incubator-like setting, and then moves them to a multitenant space where they can develop and grow in spaces designed to their own specifications.

One such company, Phytodyne, Inc., this year made the move from the Iowa State Research Park's wet lab incubator to the multi-tenant space. Phytodyne is one of the first business ventures based on research sponsored by Iowa State's Plant Sciences Institute. It offers a technology called "genome editor" as a service to companies and research groups that want to modify plant genes to produce new crop traits.

Phytodyne recently signed a partnership agreement with the German company BASF Plant Sciences to deliver genes of interest into soybeans. "It's a really important achievement for us that an established company is interested in what we're doing," says Dan Voytas, one of Phytodyne's founders and an Iowa State University professor of genetics, development and cell biology. "It provides a validation."

Over the past three to five years of the fifteen or so years Iowa State's Research Park has been in existence, "we are seeing more and more activity in the life science and biotechnology company arena," says Steve Carter, Iowa State University Research Park director. These businesses have very demanding infrastructure needs, which are expensive and widely variant, he explains.

The advent of the Roy J. Carver Co-Laboratory is important for providing the pre-company laboratory. In the early stages of looking into the commercial potential of a particular research idea, the project needs to be removed from the university lab setting, isolated from other projects so the science can be moved ahead without conflicts of interest. As the Plant Sciences Institute attracts more researchers who keep making advances, more commercial opportunities will arise.

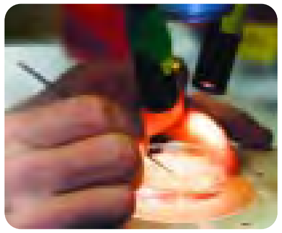
The new biologics facility, which will be built at the Research Park, will create more space for start-up businesses. Funding for the new facility is provided in part by the newly created Grow Iowa Values Fund.

The main feature of the facility is a protein extraction plant. Scientists from the Plant Sciences Institute's many centers will work to develop manufacturing techniques to extract valuable proteins from transgenic corn and other genetically engineered plants grown in Iowa. Many of these proteins will be used to make things like biopharmaceuticals, environmentally friendly industrial enzymes, or other biobased products.

The facility will give Iowa State researchers and entrepreneurs an opportunity to develop protein extraction business or businesses involving the use of novel protein products.

Fledgling companies mature under Steven Carter's watchful eye.

NEW PROTEIN ANALYSIS OPPORTUNITIES IN THE ROY J. CARVER PROTEOMICS FACILITY



Thanks to two new instruments in the Roy J. Carver Co-Laboratory Proteomics Facility, Iowa researchers now have powerful tools to examine the thousands of proteins produced by plants.

The only one of its kind in Iowa, the new differential gel electrophoresis workstation makes it possible to pick out and identify single proteins from among thousands of others.

This technology can be used to identify important new proteins made by plants or to diagnose plant ills—much like molecular medicine is used to treat human conditions.

One group of Iowa State University scientists is planning to use the instruments to study the protein changes that occur when a plant is under stress, such as those caused by drought.

Over half the potential yield is never realized from plants growing in stressful conditions, says David Oliver, a professor of genetics, development and cell biology, "By studying protein changes during drought, we might be able to keep plants productive even under stressful conditions."

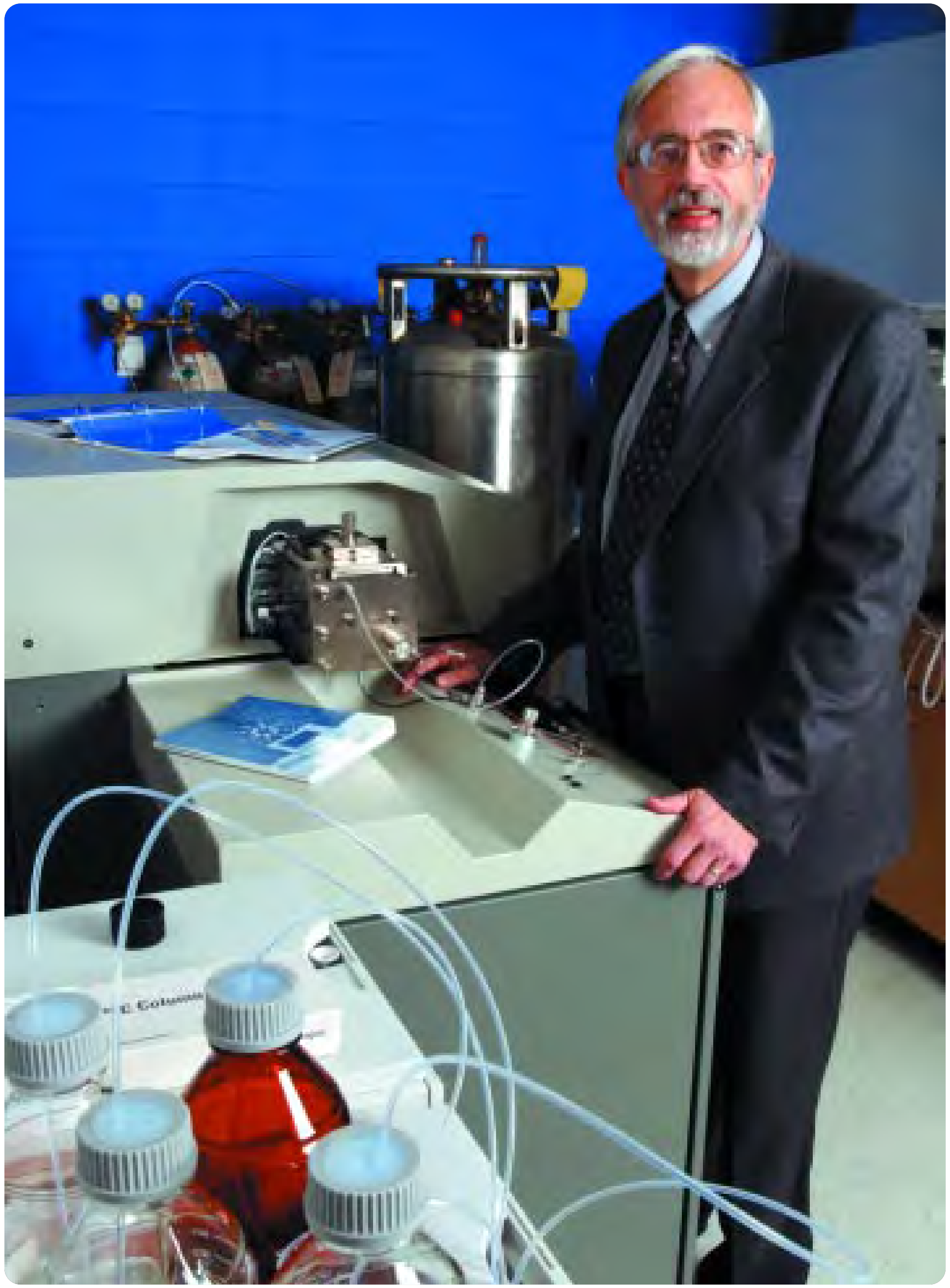
Researchers can also look at normal cell proteins and visualize the effects of genetic changes to those proteins.

Compared to genes, proteins are difficult to study because many crucial proteins are present in cells in tiny amounts.

The differential gel electrophoresis workstation uses robotics to automatically punch out single proteins from a two-dimensional gel, and break them into individual peptides using a digestive enzyme.

A second instrument called a quadrupole-time of flight tandem mass spectrometer reads the peptide pattern of the individual protein of interest. This pattern is compared with those held in a publicly available database called "ProteinProspector" that is maintained at the University of San Francisco and holds the theoretical protein composition for many genes.

"It's a fantastic tool," says Louisa Tabatabai, a professor of biochemistry (collaborator) and professor-in-charge of the Protein Facility in the Office of Biotechnology. "Not only can we immediately get the sequence and identity of proteins from the two-dimensional gels, we can see the total complement of proteins in a cell due to the mass spectrometer analyzer's ability to detect proteins present in minute amounts."



A team of experts headed by David Oliver selected the best machine for the job.

BIOFORTIFIED CORN TO FIGHT VITAMIN A MALNUTRITION IN THIRD-WORLD COUNTRIES

Nutrition researcher Wendy White, along with plant molecular biologists Steve Rodermel and Kan Wang are part of an international team that will work to improve the vitamin and mineral content of staple crops like corn, wheat, rice, and beans.

The group is working to boost the beta-carotene content of corn. The human body converts beta-carotene to vitamin A, a vitamin essential for normal growth and development, maintaining healthy eyes, and resistance to infectious diseases.

Economist Howarth Bouis recently outlined the rationale for providing biofortified plant seeds to enable remote populations to grow their own nutrient-enriched foods, a theory he has been promoting for over a decade.

An effective approach according to Bouis is to develop crops already fortified and give the seeds to local farmers. Then the crops will be grown and consumed year after year, making these rural populations independent of governmental aid or upheaval for their nutritional well being.

HarvestPlus, a program developed by the International Food Policy Research Institute will test Bouis' theory in an interdisciplinary initiative that will focus on 48 developing countries in sub-Saharan Africa that use corn as their staple food.

"The HarvestPlus humanitarian effort draws on expertise from all over the world, including social scientists, communications experts, economists, plant scientists, nutritionists, and agronomists," explains White, an associate professor of food science and human nutrition.

The Iowa State researchers bring unique expertise to the project. HarvestPlus is pursuing both plant breeding and plant biotechnology approaches to enhance the beta-carotene content of corn.

White, who developed a high-sensitivity approach for screening candidate biofortified foods, will be measuring how much beta-carotene in the corn is actually available for absorption and subsequent conversion to vitamin A in the body.

By using a high-sensitivity coulometric array electrochemical detection method, White's group will measure how much of the beta-carotene from the corn is truly being absorbed and converted into vitamin A and how much is simply being ingested but not used by the body.

White's data will tell researchers who are designing the biofortified corn how effective their plants are at providing vitamin A nutrition. Seeds from the best corn candidate will be produced and given to poor rural farmers to grow.

"This project has opened a whole new horizon for me," says White. "Realizing what I do day-to-day impacts so many people—from undergraduates to world food policy makers to the millions who suffer from vitamin A malnutrition—has put my research efforts on an entirely new scale."

Wendy White examines the bioavailability of corn beta-carotene.

CORN POLLEN WHEREABOUTS HELP CREATE RISK MANAGEMENT TOOL

Developing public confidence in genetically modified agricultural products is the goal for an interdisciplinary team of Iowa State researchers. The group is associated with the recently established Biosafety Institute for Genetically Modified Agricultural Products (BIGMAP).

The researchers are drawing on their respective expertise in areas as diverse as plant transformation, economics, statistics, grain harvesting and processing, weather risk calculation, and genetics to design a science-based risk assessment tool that will help public policy makers, regulatory groups, and individual growers safely produce genetically modified agricultural products—a pioneering economic opportunity in agriculture for the state of Iowa.

"So long as the risks associated with growing pharmaceutical corn in Iowa are unknown, we will not be able to manage these risks, or even make intelligent choices about our comparative advantage in this area," explains Dermot Hayes, BIGMAP team member and Pioneer Chair of Agribusiness. Therefore a key project for the Public Policy Task Force is to measure the benefits and costs associated with growing these crops in Iowa.

Growing pharmaceutical corn in Iowa does indeed come with certain risks. Commodity corn will ultimately surround every biopharmaceutical cornfield. There is a possibility that pollen will disperse from the biopharmaceutical corn into the surrounding commodity cornfields.

When corn releases its pollen in July and early August, wind speed, humidity and air temperature determine whether commodity fields might be exposed to viable pollen coming from a pharmaceutical cornfield nearby.

"It is important to quantify the movement of pollen in the atmosphere to control the genetic purity of the seed," explains Mark Westgate, BIGMAP team member and an associate professor of agronomy.

Westgate and his colleagues are designing a system to track the movement of corn pollen grains in the atmosphere. Using a system called "ground truthing," they are measuring atmospheric conditions and pollen deposition using pollen traps at key locations surrounding the fields, to relate pollen dispersal to local weather conditions. Their model will be one component of the BIGMAP risk-assessment tool.

Mark Westgate explains how to track drifting pollen.

Westgate is optimistic that growing pharmaceutical corn in Iowa will be "manageable" if the team can identify the key risks and develop rational strategies to minimize them.

According to BIGMAP Director Manjit Misra, who is also a professor of agricultural and biosystems engineering and director of the Seed Science Center, the tool will be developed to assess the risk of growing, processing, and purifying two pharmaceuticals that could be produced in corn. The tool can be used as a template for risk assessment of other plant-made pharmaceuticals.

THE CENTERS AND TASK FORCES OF THE PLANT SCIENCES INSTITUTE

Plant Sciences Institute Council *First row (from left): Robert Jernigan, Paul Flakoll, Deanne Brill, Charlotte Bronson, Kan Wang, Manjit Misra, Alicia Carriquiry. Second row (from left): Dermot Hayes, Patrick Schnable, Alan Myers, Stephen Howell, Basil Nikolau, Kai-Ming Ho. Third row (from left): Kendall Lamkey, Lawrence Johnson, Charles Glatz. Not pictured: Teddi Barron, Marika Jones, Cheryl Kamman, Mark Westgate.*

CENTERS

PLANT SCIENCES INSTITUTE
Stephen H. Howell, Director
The Plant Sciences Institute is a large interdisciplinary organization on campus, composed of nine research centers and three task forces, each focused on specific areas of the plant sciences.

CENTER FOR CROPS UTILIZATION RESEARCH
Lawrence A. Johnson, Director
The center facilitates basic and applied mission-oriented research to find new uses for midwestern crops and identify uses for potential crops.

CENTER FOR DESIGNER CROPS
Basil J. Nikolau, Director
The center facilitates and sponsors innovative and fundamental molecular research that will lead to a comprehensive understanding of plant metabolism.

CENTER FOR DESIGNING FOODS TO IMPROVE NUTRITION
Paul J. Flakoll, Director
The center fosters interdisciplinary research to improve nutrition and promote good health through new and traditional foods.

CENTER FOR PLANT GENOMICS
Patrick S. Schnable, Director
The center develops and deploys genomic technologies to better understand the organization of plant genomes and the genes that control plant growth and development.

CENTER FOR PLANT RESPONSES TO ENVIRONMENTAL STRESSES
Charlotte R. Bronson, Interim Director
The center conducts fundamental research on how plants detect and respond to biotic and abiotic stresses in their environment and how plants can be modified to tolerate those stresses.

CENTER FOR PLANT TRANSFORMATION
Kan Wang, Director
The center develops more efficient methods to produce transgenic plants that will be safe for human health and the environment.

LAURENCE H. BAKER CENTER FOR BIOINFORMATICS AND BIOLOGICAL STATISTICS
Robert L. Jernigan, Director
The center develops advanced methods, algorithms and programs for acquiring, analyzing, and communicating genomic data to plant scientists worldwide.

RAYMOND F. BAKER CENTER FOR PLANT BREEDING
Kendall R. Lamkey, Director
The center integrates basic research breeding methods and germplasm enhancement in the development of improved cultivars for corn, forages, soybeans, popcorn, small grains, and potential new crops.

SEED SCIENCE CENTER
Manjit K. Misra, Director
The center is a national center of excellence in seed research, education, and technology transfer. The center also is a leader in international seed programs, as well as home to the National Seed Health System.

TASK FORCES

PUBLIC POLICY TASK FORCE
Dermot J. Hayes, Leader
This task force initiates, coordinates and communicates activities in the areas of economics, sociology, risk assessment, and business as they relate to agricultural biotechology.

BIORENEWABLES TASK FORCE
George A. Kraus, Leader
This task force advises the Biorenewable Resources Consortium in its research on biobased products leading to greater utilization of bioproducts and bioenergy from renewable resources.

IOWA GRAIN QUALITY INITIATIVE TASK FORCE
Charles R. Hurburgh, Leader
This task force's mission is to increase economic returns to Iowa agriculture by creating a long-term vision for sustainable growth in markets for user-specific grains.

TWENTY-THREE EXCEPTIONAL GRADUATE FELLOWS SEIZE THE OPPORTUNITY TO STUDY AT IOWA STATE

Over 600 undergraduate and nearly 400 graduate students study various aspects of plant sciences at Iowa State University. In 2000, a program was inaugurated to enrich the graduate program by bringing the "best and brightest" graduate students in the plant sciences to Iowa State.

From fall 2000 to 2003, the Plant Sciences Institute funded 23 outstanding graduate fellows. The institute plans to continue to broaden its search for future graduate fellows to build a strong and sustaining graduate training program in the plant sciences at Iowa State University.

PSI Fellows gather for a recent event in the Roy J. Carver Co-Laboratory. First row, from left: Rhonda Graef (sustainable agriculture), Andrea Scarpa (interdepartmental plant physiology), Megan O'Rourke (entomology), Lankum Wu (interdepartmental plant physiology), Heidi Kratsch (interdepartmental plant physiology), Xianyan Kuang (interdepartmental genetics), Young Jin Chun (ecology, evolutionary and organismal biology), Heather Babka (interdepartmental genetics). Second row, from left: Xu Li (biochemistry, biophysics and molecular biology), Fei Yu (interdepartmental plant physiology), Shannon Schlueter (bioinformatics and computational biology), Ryan Rapp (ecology, evolutionary and organismal biology), PSI director Steve Howell, Brent Hulke (agronomy), Joe Robins (interdepartmental genetics), Lex Flagel (interdepartmental genetics), Ryan Stewart (horticulture).

SIX IOWA STATE RESEARCH PROJECTS AWARDED GRANTS BY THE PLANT SCIENCES INSTITUTE

The Plant Sciences Institute awarded start-up funds to six Iowa State research projects. They were selected for their excellent science, probability for external funding and potential to foster long-term collaborations. Grants ranged from $10,000 for one year to $60,000 for two years.

ORGAN-SPECIFIC DETERMINANTS OF ABSCISSION COMPETENCE
C. Lashbrook, horticulture

STRUCTURE-FUNCTION ANALYSES OF THE PHYTOPHTHORA RESISTANCE GENE RPS 1-K RELATING TO CELL DEATH
M. Bhattacharyya, agronomy

USING GENETICS AND PROTEOMICS TO LOCALIZE OXIDATIVE DAMAGE WITHIN ARABIDOPSIS CELLS
D. Oliver, genetics, development and cell biology

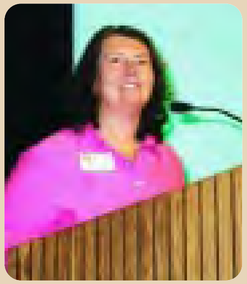
METABOLMICS ANALYSIS OF ACYL-COA POOLS IN PLANTS
B. Nikolau, biochemistry, biophysics and molecular biology; and E. Yeung, chemistry

SYSTEMS BIOLOGY: GENOME, GENETIC NETWORK AND EVOLUTION
X. Gu, genetics, development and cell biology; and H. Liu, mathematics

IDENTIFICATION OF VARIETIES AND TRANSGENIC EVENTS WITH SPECTROSCOPY
C. Hurburgh, agricultural and biosystems engineering

TRANSPOSABLE ELEMENTS JUMP-START DISCUSSIONS AT THE PLANT SCIENCES INSTITUTE'S FOURTH ANNUAL SYMPOSIUM

The Plant Sciences Institute's fourth annual symposium brought together many of the world's foremost scientists on plant transposable element research—an area in which Iowa State has produced scientific leaders. The symposium was organized by Iowa State scientists Tom Peterson, Marit Nilsen-Hamilton, and Dan Voytas; Virginia Walbot (Stanford University); Andy Pereira (Plant Research International, Netherlands) and Hirohiko Hirochika (National Institute of Agrobiological Sciences, Japan). Topics ranged from transposon biology to transposon mechanisms to applications of transposon-mediated recombination for plant genome modification.



Virginia Walbot, member of the PSI Board, speaks on maize transposons at the fourth annual symposium.

ADMINISTRATIVE REPORT

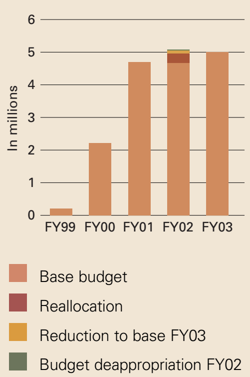
FACULTY AFFILIATES

More than 200 Iowa State faculty are affiliated with the nine centers and three task forces of the Plant Sciences Institute. These faculty members represent more than 30 departments and seven colleges. Funding to the Plant Sciences Institute has been used to hire top-notch new faculty and to support facilities such as the new proteomics facility located in the Roy J. Carver Co-Laboratory. To date, 17 faculty members have been hired in the Departments of Agronomy; Agricultural and Biosystems Engineering; Genetics, Development and Cell Biology; Plant Pathology; Chemistry; Computer Science; Horticulture; Chemical Engineering; Ecology, Evolutionary and Organismal Biology; and Biochemistry, Biophysics and Molecular Biology.

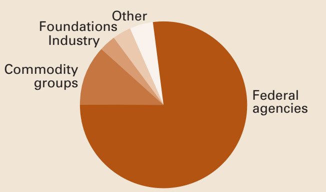
FINANCES

Plant Sciences Institute–affiliated faculty generated over $26 million in external funds in fiscal year 2003. External funds were largely derived from federal agencies such as the United States Department of Agriculture ($9.9M), the National Science Foundation, ($4.6M) and the National Institutes of Health ($4.4M). State of Iowa funding, which was $200,000 in FY99, increased to more than $5 million in FY02-FY03.

PLANT SCIENCES INSTITUTE STATE FUNDING FY99-FY03



PLANT SCIENCES INSTITUTE EXTRAMURAL FUNDING SOURCES



Federal agencies	$18,472,880
Commodity groups	2,789,201
Industry	767,132
Foundations	854,020
Other	1,087,913
Total	$23,971,146

PLANT SCIENCES INSTITUTE ORGANIZATION

View from the northwest of the Roy J. Carver Co-Laboratory, the administrative home of the Plant Sciences Institute.

PLANT SCIENCES INSTITUTE BOARD

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Director, Seed Science Center; Professor, Department of Agricultural and Biosystems Engineering

Alan M. Myers
Professor and Chair, Department of Biochemistry, Biophysics and Molecular Biology

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Director, Center for Designer Crops; Professor, Department of Biochemistry, Biophysics and Molecular Biology, Department of Food Science and Human Nutrition

Patrick S. Schnable
Director, Center for Plant Genomics; Professor, Department of Agronomy, Department of Genetics, Development and Cell Biology

Kan Wang
Director, Center for Plant Transformation; Professor, Department of Agronomy, Department of Genetics, Development and Cell Biology

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