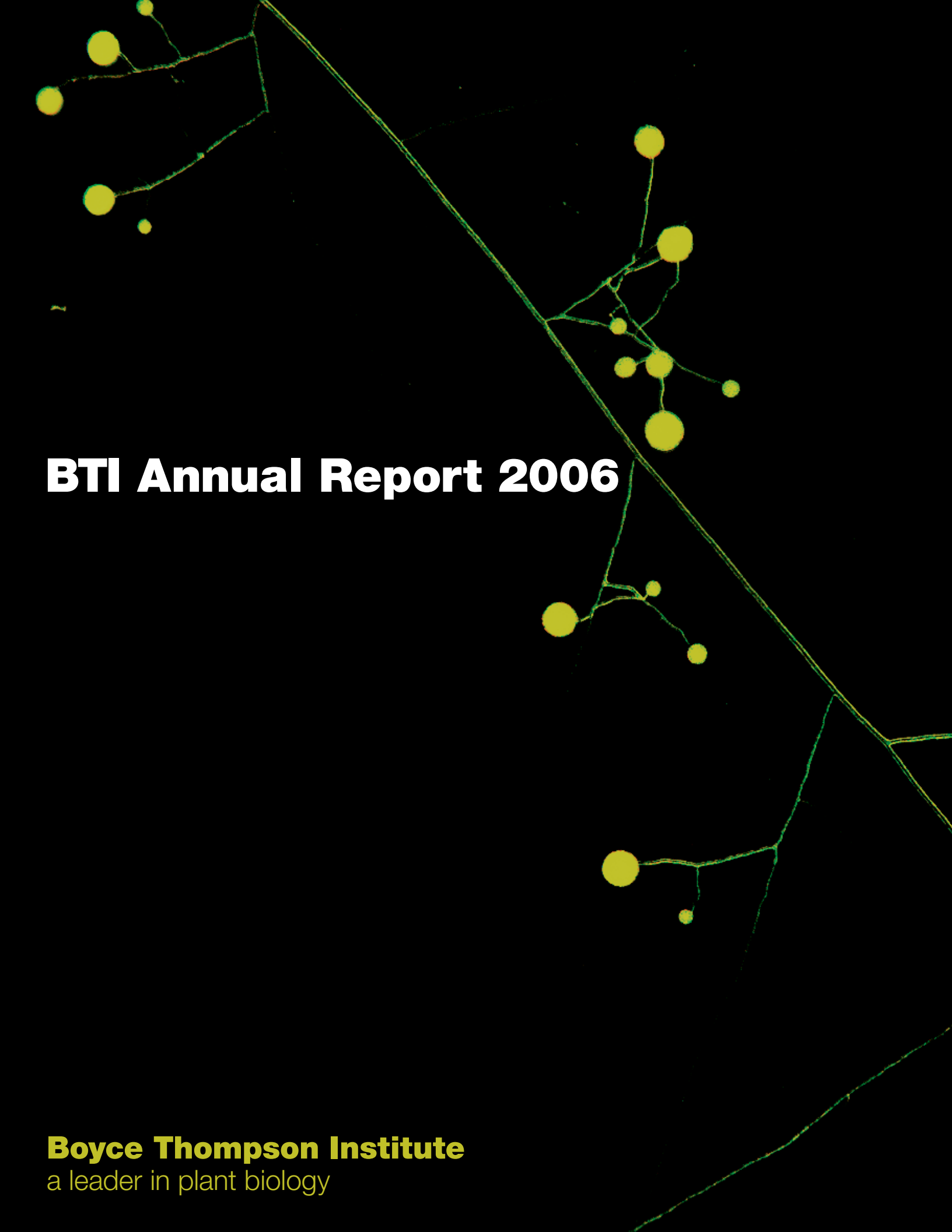


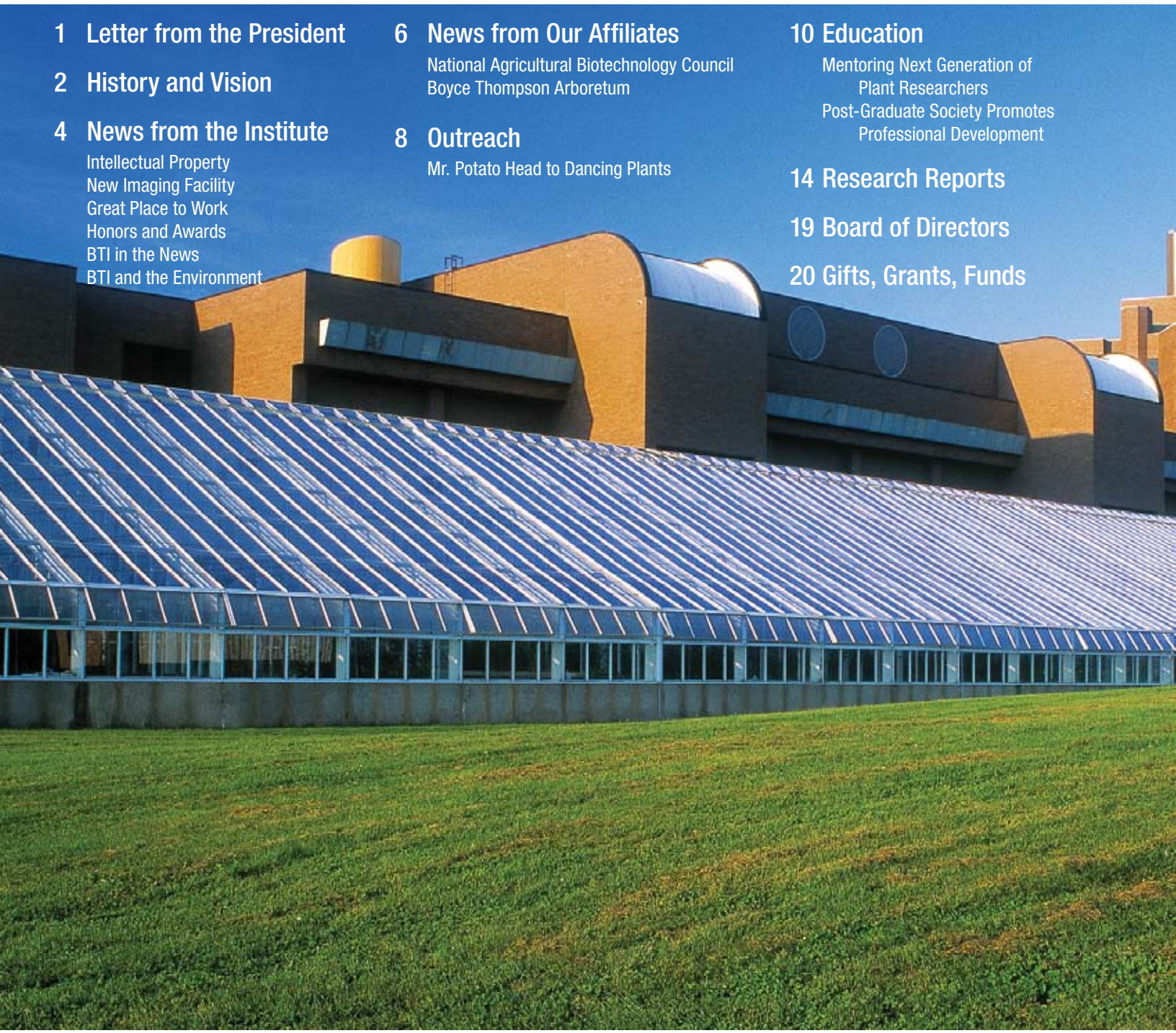
BTI Annual Report 2006

Boyce Thompson Institute
a leader in plant biology

in this issue





letter from the president

BTI is at its heart a research enterprise, exploring the universe of plant biology for the benefit of society. Yet BTI is also a waypoint in many careers, both in our research and support sectors. This year's report features what—in many ways—is the most important group of short-term employees, our postdoctoral fellows, or postdocs.

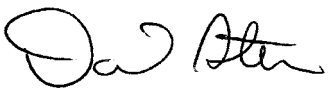
In 2005, a survey of nearly 8,000 postdocs was conducted by Sigma Xi, a scientific society founded at Cornell in 1886 and now represented in more than 100 countries. According to this survey (http://postdoc.sigmaxi.org), there are more than 50,000 postdocs in the U.S., and at this writing there are 41 at BTI who, along with 20 technicians and 13 Cornell graduate students, form our day-to-day research corps. Postdoctoral training is a form of apprenticeship that has a long history, but has become much more prevalent in the life sciences over the past 20 to 30 years. Given that postdocs today account for over half of the BTI research staff and more than one-third of employees overall, we owe much to them for our success.

The Sigma Xi survey results were somewhat surprising in that they identified degree of formal training as a strong predictor of postdoc satisfaction. In retrospect, that is an understandable outcome, because true apprenticeships fully prepare the trainee for independence in their career track. Postdocs, however, often find that while they are well trained in research, neither the breadth of career choices, nor ancillary skills critical to success as an independent faculty member, are adequately emphasized.

Several years ago, a BTI Post-graduate Society (PGS) was formed at the behest of our external Research Oversight Committee. The PGS (which includes graduate students) is described in this report, and I believe it has delivered tremendous results through a creative array of programs. BTI also pays special attention to postdocs as our benefits packages are updated, and each postdoc receives formal feedback annually. Perhaps one measure of our postdoc program is that it was among the best in the country in the last two surveys conducted by *The Scientist:* 12th in 2006 and 9th in 2007.

2006 also saw a milestone for our research capabilities with the dedication of an imaging facility featuring a confocal microscope. The uses of fluorescent markers in plant cells have burgeoned in recent years, and this NSF-funded instrumentation will make a dramatic difference in the ability of BTI scientists to gaze into cells in three dimensions and in real time. Please see the scientists' research reports for some of the applications of this technology.

BTI emphasizes research, but our associated missions of education and environmental responsibility are also part of what makes us unique. Our summer internship program is in high demand, and other public communication forums such as *Science Cabaret* and *MicrobeWorld* are popular and play important roles in bridging the gap between the laboratory and the community. I am indeed fortunate to be in the president's chair in the midst of such a dynamic, creative group of scientists and support staff. Please explore the 2006 *Annual Report* and let yourself in on some of the secrets.



David Stern

history

the Vision *of Research and Mankind's Future*

William Boyce Thompson was a hard-headed realist, but also a dreamer. He was ruthless on Wall Street, but generous with his fortune. He found solace from the pressures of the world in his garden. He questioned why some plants were susceptible to diseases and pests, but others were not. He wondered what made plants grow—water, air, or sunlight?

He stated, "When I have enough money, I am going to build a laboratory to study some of the fundamental things . . . a good place to study them would be in the realm of plants. Any principles concerning the nature of life that you can establish for plants will help you to understand man, in health and in disease. So, by helping man to study plants, I may perhaps be able to contribute something to the future of mankind."

Thompson's concern for the future of mankind arose from a visit to Russia during the Russian Civil War and the belief that future world political stability would depend on adequate food supplies. "There will be 200 million people in this country pretty soon. It's going to be a question of bread, of a primary food supply . . . I'll work out some institution to deal with plant physiology, to help protect the basic needs of the 200 million," he stated.

The Boyce Thompson Institute for Plant Research was founded in 1924 in Yonkers, NY.

Research at BTI has led to advances in human health and medicine, agriculture, and environmental science and conservation. Basic biological research on plants has led to improved vaccines and methods for delivering medications to humans. Other research has led to new ways of controlling plant diseases, insect predators, and problematic weeds, thereby improving crop yields. BTI research has contributed to air quality standards and water decontamination efforts.

Thompson's vision has been realized. As its scientists tackle the challenges of the 21st century, from improving human health and nutrition to decreasing society's negative impacts on the environment, BTI continues to further Thompson's mission to improve human welfare through basic plant research and education.

"Any principles *concerning the nature of life that you can establish for plants will help you to understand man, in health and in disease.*"

INTELLECTUAL PROPERTY

BTI currently holds 45 U.S. patents and 45 foreign patents. The Institute's intellectual property portfolio continues to benefit from the innovation of its scientists, with four new patents issued in 2006:

Clonal Cell Lines Derived from bti-tn-5b1-4
INVENTORS:
Robert Granados and Guoxun Li

Nucleic Acids Encoding *Pseudomonas* Hop Proteins and Use Thereof
INVENTOR:
Greg Martin

Novel Salicylic Acid-Binding Protein Encoding Nucleic Acid, SABP2, and Methods of Use Thereof
INVENTORS:
Daniel Klessig and Dhirendra Kumar

Vectors and Cells for Preparing Immunoprotective Compositions Derived from Transgenic Plants
INVENTOR:
Joyce Van Eck

NEW IMAGING FACILITY

Researchers at BTI can now get "up close and personal" with plant cells in new ways. This facility greatly modernizes BTI's imaging capabilities. Maria Harrison and co-PI Greg Martin received an NSF grant award to acquire a fluorescence stereoscope and a laser-scanning confocal microscope, allowing time-sensitive studies in-house. Conventional microscopy produces a somewhat hazy image due to simultaneous emission of light from many points on a specimen. Confocal microscopy produces clearer results by detecting light from only a small portion of the specimen. Striking three-dimensional images, assembled from a series of two-dimensional pictures, can be viewed from any angle. Uses include tagging parts of a cell with fluorescent molecules to distinguish structures, optical dissection, and creation of time-lapse movies. With so many possibilities, plant cell imaging promises to usher in a new era of "three-dimensional biology" at BTI.

A GREAT PLACE TO WORK

BTI has been officially recognized as a great workplace. It was ranked #12 in *The Scientist's* 2006 survey of Best Places to Work for postdocs in North America. Individuals expressed particular satisfaction with the facilities and the communication among researchers. In 2006, the Institute was certified by the Tompkins County Living Wage Coalition as one of 17 "living wage employers" committed to providing fair wages and access to health care.

Just as when it opened in 1924, BTI continues to employ top-notch scientists and staff. However, times have changed as have employees' needs. In 2006, BTI introduced new family-friendly benefits, including flexible work arrangements and paid parental leave following the birth of a child. BTI also made a successful transition to a new retirement plan, shifting away from a defined benefit plan to a defined contribution plan, created to meet the needs of an increasingly diverse population, and to ensure sustainability for the next generation of scientists and staff.

HONORS AND AWARDS

Gary Blissard was elected to the Council of the American Society for Virology (ASV), its governing body.

Plant Breeding and Genetics graduate student **Liza Conrad** received the Barbara McClintock Award, which recognizes "a graduate student with the best potential and greatest background merit" in the plant sciences at Cornell. Ms. Conrad began work in Tom Brutnell's lab as a technician, and continued with her dissertation research on transposons (or "jumping genes") in maize.

Liza Conrad

Greg Martin was the Grand Marnier Foundation Guest Lecturer at the Pasteur Institute in Paris.

Joyce Van Eck received an "Above and Beyond" award from Dow AgroSciences for her work on plant-made vaccines. This award is given to an individual "who has succeeded beyond worldly expectations" and whose contributions have significantly benefited society.

BTI IN THE NEWS

Growing medicine—In February, the *Ithaca Journal* published an article featuring Joyce Van Eck's role in the first approved plant-made vaccine. Dow AgroSciences has licensed three BTI patents on methods to make pharmaceuticals in cultured plant cells, including production of a vaccine to protect poultry against Newcastle disease.

Scientist's work opened doors to insulin inhaler—Emeritus Scientist Carl Leopold was featured in an article, also in the *Ithaca Journal*, in February. As a result of his research on seed dormancy, Leopold developed a drying technique now employed by Pfizer and Nektar Therapeutics to produce inhaled insulin to manage diabetes.

MicrobeWorld: Discover unseen life on earth—Greg Martin and Joyce Van Eck spoke on the daily *MicrobeWorld* segment on National Public Radio about plants' resistance to bacterial pathogens and how some pathogens can be used as vehicles to insert new genes into plants. Gary Blissard and Emeritus Scientist Robert Granados discussed baculoviruses, explaining how seemingly aggressive baculoviruses can be utilized to benefit humans and the use of baculoviruses in pest control and production of a vaccine against cancer.

BTI AND THE ENVIRONMENT

Earth Week

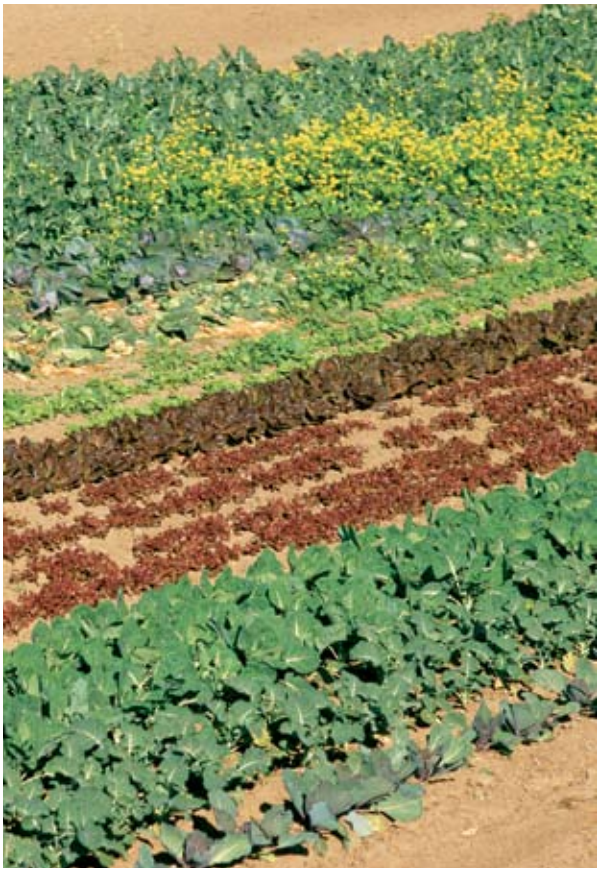
For the Institute's second annual Earth Week Volunteer Day, on April 20th, 17 employees set aside their usual responsibilities to improve the local environment. The BTIers restored a stream bank along Six Mile Creek in Slaterville—a project arranged by the Cayuga Lake Watershed Network—and pulled invasive garlic mustard in the Finger Lakes Land Trust's Lindsay Parsons Biodiversity Preserve. Employees found the experience educational and enjoyed the opportunity to benefit the environment.

Energy Savings

Over the past few years, Larry Russell, BTI's director of operations, has led an overhaul of the Institute's building systems to reduce energy usage and costs. In 2001, BTI began a $1.2 million project to improve the growth facilities, resulting in not only decreased energy consumption but also improved research capabilities. In 2004, BTI began a multi-pronged project to regulate building temperature more effectively. Originally, hot water for heating had been delivered year-round, even in summer. Temperature control valves were installed to correct this design flaw. Additionally, laboratories were outfitted with sensors to reduce airflow when unoccupied. 2005 saw improvements to chilled water and airflow controls. Greenhouse improvements continued in 2005 and 2006, with the centerpiece being installation of the Argus Greenhouse Control System, accompanied by upgrades to greenhouse ventilation and infiltration. The Argus system is state-of-the-art and gives precise monitoring and control capabilities. A zone-based strategy has improved energy management throughout the building, with in-house personnel monitoring energy usage. BTI continually seeks energy-saving opportunities as part of its environmental mission, particularly in view of increased concerns over climate change.

BTI is now saving more than $250,000 annually as a result of these projects, even as unit energy costs have inexorably risen. Put another way, energy usage averaged 76.9 billion BTU/year before these projects were begun (1 BTU is the quantity of energy required to raise the temperature of 1 lb of water by 1°F). In the 2005–2006 academic year, energy usage decreased to 36.7 billion BTU. The annual saving of 40.2 billion BTU is equivalent to 321,830 gallons of gasoline or 2,010 cords of firewood. Based on the average family home consumption of 107.3 million BTU/year, BTI's annual energy savings could fuel 375 homes for a year.

The Argus Greenhouse Control System provides automatic regulation of greenhouse environment and irrigation.



NATIONAL AGRICULTURAL BIOTECHNOLOGY COUNCIL

The primary goal of the National Agricultural Biotechnology Council (NABC) is to provide an open forum for the discussion of major issues of agricultural biotechnology. NABC was founded in 1988 by then-BTI president Ralph W. F. Hardy and Robert B. Nicholas, a Washington, DC, lawyer and former government staffer. The 34-member organization comprises not-for-profit agricultural research, education, and extension organizations based in Canada and the United States.

In February 2006, the NABC published *Recommendations for Management Practices for Field Trials with Bioengineered Plants,* a 17-page booklet providing guidance to NABC-member institutions on field research practices involving genetically engineered crops. This represented a new and different role for NABC, in not merely establishing consensus on scientific directions, but actually suggesting uniform practices that will increase public confidence and communication between organizations that sponsor university research on transgenic plants and their farm neighbors.

The NABC held its 18th annual meeting in June at BTI and at Cornell University's Geneva campus. The meeting, Agricultural Biotechnology: Economic Development through New Products, Partnerships, and Workforce Development, addressed the role universities and state and federal governments play in developing and moving research into the marketplace.

BOYCE THOMPSON ARBORETUM

Boyce Thompson Arboretum in Superior, Arizona, is home to a wide variety of plant and animal life. This past September, a rare hummingbird was sighted there. Clearly different from any species found in Arizona, its unique coloring suggests it is a hybrid of two species. Blue feathers on the head and shoulders are reminiscent of violet-crowned hummingbirds, while green feathers on the wings and back and a distinctive orange-colored bill are similar to those of broad-billed hummingbirds. It took up residence in the Hummingbird-Butterfly Garden at the Arboretum and remained there throughout the winter.

For the past few years, broad-billed hummingbirds have over-wintered at the Arboretum, the northernmost limit of their range in Arizona. However, violet-crowned hummingbirds seldom are found north of the Mexican border. Hybrids of violet-crowned and broad-billed hummingbirds have been recorded only twice before—in March 1887 in Mexico and July 1905 in the Huachuca Mountains of Arizona.

William Boyce Thompson established the 320-acre Boyce Thompson Arboretum in 1929 with the mission "to instill in people an appreciation of plants through the fostering of educational, recreational, research, and conservation opportunities associated with arid-land plants." As demonstrated by his founding of the Institute and the Arboretum, Thompson had a strong commitment both to research and to public education. The Arboretum continues its founding mission of nurturing appreciation and knowledge of wildlife while providing a refuge for unique plants and animals, such as this hybrid hummingbird.

Mark Bierner, director of Boyce Thompson Arboretum, commented, "The Arboretum is a place where people can come to enjoy an experience rather than a simple activity. Unusual sightings, such as the hybrid hummingbird, make the experience unique and special—something that is unlikely to be found elsewhere."

"The Arboretum is a place where people can come to enjoy an experience rather than a simple activity. Unusual sightings, such as the hybrid hummingbird, make the experience unique and special—something that is unlikely to be found elsewhere."

outreach

Although BTI is primarily known as a plant research institute, education plays a central role in its mission. Outreach programs provide opportunities to share research objectives and results with the public. In-house programs—internships, graduate student training, postdoctoral fellowships—provide mentoring for the next generation of plant researchers, helping them realize their goals as innovative and informed scientists.

Outreach programs at BTI are directed to people of all ages and backgrounds, from grade-school children to senior citizens, to foster understanding and appreciation of science, especially the important roles of plants and plant research in society.

From Mr. Potato Head to Dancing Plants: Outreach at BTI

What can Mr. Potato Head teach children about plants? In BTI's *Nature Explorers* outreach program, a weekly addition to an after-school program that uses enjoyable activities to teach young students about nature and plants, Mr. Potato Head and other members of his family, including Mrs. Tomato Head and Ms. Eggplant, demonstrate the diversity of the *Solanaceae* family—with a little help from Joyce Van Eck. With an assortment of pipe-cleaners and "stick-on" accessories, children create their own solanaceous characters while discovering the similarities and differences that have evolved among these fruit- and tuber-producers. This past year, *Nature Explorers* was held at two Ithaca schools: at Northeast Elementary School in the spring and at Caroline Elementary School in the fall. Elizabeth Fox, BTI's outreach coordinator, led *Nature Explorers* groups in interactive educational projects, ranging from extracting strawberry DNA (and drinking strawberry milkshakes!) to creating leaf collages.

Summer internships in BTI's Plant Genome Research Program (PGRP) give high-school and college students opportunities to set aside their textbooks and gain hands-on experience at the lab bench, in the greenhouse, and in the field. Twenty-two college and high-school students from diverse backgrounds were PGRP interns in 2006, funded by the National Science Foundation (NSF), private donations, and research grants. Under the daily guidance of graduate students and postdocs at BTI, Cornell University, and the U.S. Department of Agriculture, the interns pursued research results and heard talks on topics such as biotechnology, plant development, and genome evolution. The summer program culminated in the *Colonel's Cup Challenge* symposium; the award for best presentation went to April Dobbs from the Giovannoni lab and the award for best poster went to Kenneth Liu from the Stern lab.

The internships encourage students' academic development in many ways. Michelle LeRoux, a senior at Colgate University in Hamilton, NY, felt that she developed many skills that will be useful in her honors project. "The PGRP internship was a really great program and I got so much out of it. . . . Not only the research but also all the opportunities we had to talk with the different PIs were really valuable." She plans to work for a year as a laboratory technician and then may continue her studies as a graduate student in plant biology,

possibly at Cornell. Lillian Lewis, a sophomore at Penn State, had been interested in pursuing medical school, but “now I am more interested in plants!” she said.

Promoting stronger science programs, both in and out of the classroom, is part of BTI’s education mission. In the summer, teachers from throughout New York State attended a four-day NSF–supported curriculum-development workshop at BTI focused on classroom educational modules. “Keeping current in the sciences is essential for good teaching,” said one attendee. Teachers appreciated the opportunity to hear about the newest research in plant biology and discuss complex topics with experts in their fields. A follow-up workshop in the fall helped the teachers further develop their curricula and prepare them for testing in their classrooms.

Enlightening and engaging adults with science is another goal of the outreach program. In collaboration with the Museum of the Earth, BTI brought the multimedia exhibit *sLowlife* to Ithaca in December 2006. It was shown through April 1, 2007. *sLowlife* utilizes time-lapse photography to show how plants move, grow, and interact with the environment.

Science Cabaret, another successful outreach program for the local community, encourages people’s interest in and involvement with science by providing an enjoyable forum for discussion with experts. Subject matter included the evolution of religion, the importance of pheromones, and the psychology of race relations. Roger Hangarter, the creator of *sLowlife,* spoke at the November *Science Cabaret* and in BTI’s Distinguished Lecture series.

These outreach activities provide individuals at BTI opportunities to share their knowledge of and passion for plant science with the public, while fostering a closer relationship between the public and the scientific community.

Gary Blissard and Maria Harrison enjoying the *sLowlife* exhibit.

MENTORI

Pursuing postdoctoral "apprenticeships" following receipt of a doctoral degree is a tradition that has been in existence since the late 19th century. Only within the past 30 years, however, has this tradition become commonplace. In 2006, 14 postdocs left BTI to advance their scientific careers as assistant professors, research associates, and scientists within government and industry. Not only are they conducting cutting-edge research, they are sharing knowledge acquired at BTI, as well as excitement for plant biology research, with people throughout the world.

Many researchers have passed through BTI's doors as they have spawned very successful careers. These scientists credit BTI with providing a springboard to further their research and other life pursuits. Kerry Pedley, a recent postdoctoral associate in Greg Martin's lab, commented, "BTI was a wonderful place to do my postdoctoral training. I was given a lot of independence and the freedom to develop my own projects. By working closely with Greg, I was able to refine my writing skills, especially with regard to grant proposals." Pedley is now a scientist in the Foreign Disease-Weed Science Research Unit of the U.S. Department of Agriculture in Fort Detrick, MD. The following vignettes highlight stories of other former postdocs.

For many BTI postdocs, the research interests that they develop during their apprenticeships form a foundation for their career. That was the case for Fred Sack. After completing his Ph.D. at Cornell University, Sack began research in Carl Leopold's lab in 1982 with a goal of understanding the mechanism by which plants sense gravity. He conducted elegant research using movies to show cellular organelles moving in response to gravitational change. In 1984, he joined the Department of Plant Biology at Ohio State and recently moved to the University of British Columbia, where he is head of the Department of Botany. Much of his research has focused on understanding gravity sensing, specifically how gravity influences the internal organization of cells in mosses. Sack has utilized NASA space-shuttle missions to send mosses into orbit around Earth to determine how they fare in an environment with little gravity. He made the startling discovery that, in orbit, mosses develop in a spiral pattern, in contrast to the usual tangled mat. How and why reduction in gravity causes this phenomenon are enticing questions yet to be answered.

Throughout his career, Brian Federici has pursued an interest in entomology. Federici conducted postdoctoral research in Don Roberts's lab from 1972–1974, and subsequently joined the University of California at Riverside, where he is currently distinguished professor of entomology. Through studying viruses, bacteria, and fungi pathogenic to insects, Federici has contributed significantly to our knowledge of invertebrate pathology. He has been honored with many research awards, the most recent being the 2003 U.S. Department of Agriculture Secretary's Individual Honor Award, bestowed annually upon scientists who have made important contributions to agriculture, and the 2004 UCR Academic Senate Award for outstanding research. He has also received accolades for his teaching, including the UCR Senate's Distinguished Teaching Award and the National Teaching Award from the Entomological Society of America.

Other postdocs apply the skills learned to new areas of study. Kusum Sachdev received her Ph.D. in chemistry from the Central Drug Research Institute in India and, in 1985, joined Alan Renwick's lab, where she identified many plant compounds involved in plant/insect interactions. In 1987, a former colleague from India, Sandeep Gupta arrived at BTI to work with Roberts and Renwick on fungal-pathogen chemicals lethal to insect pests, a project sponsored by DuPont and the chemical company BASF. This project led to the identification of several novel secondary metabolites as insect toxins. Sachdev's and Gupta's time at BTI not only advanced insect science, but resulted in a marriage in India. As a couple, they continued to work at BTI until 1992

NG the Next Generation of Plant Researchers

when Sandeep Gupta joined ISK, a Japanese agrochemical company in California, and Kusum Gupta took a position at a nearby company. In 1994, both moved to Ricerca, a subsidiary of ISK, in Concord, OH, where they have advanced to managerial positions in separate chemical divisions of the company. They currently work on the discovery and development of drugs for cancer, Parkinson's disease, and infectious diseases. They now have two teenage daughters, who hopefully will continue their tradition of excellence in science.

Zohara Yaniv also chose a divergent path. In 1969, she joined Richard Staples's lab, where she studied protein synthesis in a rust fungus. Yaniv continued research at BTI as an assistant plant biochemist, while teaching at Manhattanville College in Purchase, NY. Through teaching, she developed an interest in medicinal plants, expertise greatly needed in Israel at that time. She returned there in 1978, joining the Department of Medicinal Crops at the Volcani Center at Bet Dagan. Since 1993, she has served as director of the Volcani Institute Unit of International Cooperation and Relations. Her current research focuses on ethnobotany, the use of metabolites of higher plants as anti-cancer agents, and biodiversity of native plants and their preservation. In 2000, Yaniv co-authored the book *Medicinal Plants of the Holy Land* with Dan Palevitch, and in 2004, she and Uriel Bachrach edited the book *Handbook of Medicinal Plants*.

Other researchers are drawn to areas outside academia and industry. Reinhard Tiburzy, a microscopist, also conducted postdoctoral studies in Staples's lab. He studied changes in DNA content in a rust fungus during the development of the appressoria, the structure used by a parasitic fungus to attach to its host. According to Staples, "Dr. Tiburzy demonstrated, against a great tide of skepticism, that . . . this biotrophic fungus is ready to replicate DNA as soon as it has made contact with its host plant, a great advantage to the fungus." In 1990, following his postdoctoral work at BTI, Tiburzy returned to the Technical University in Aachen, Germany, where he served as an assistant professor. In 2000, he altered the course of his career and established a consulting business in Aachen, where he writes articles and books on travel for various newspapers and magazines.

Those are a few examples of the many postdocs who began their careers at BTI. As each year passes, a new group arrives to explore a variety of research techniques, conceive fresh answers to pressing scientific questions, and investigate career options. And whether they become professors, choose careers in industry, or leave research altogether, the knowledge gained from the postdoctoral experience is carried with them throughout their lives.

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THE POST-GRADU

Promoting Professional Development

ATE SOCIETY

IN 2004, BTI's Post-graduate Society (PGS) was founded as a result of conversations between postdocs and the BTI Research Oversight Committee, chaired by Peter Bruns, the vice president of Grants and Special Programs at the Howard Hughes Medical Institute. The PGS receives institute support for its mission, which includes facilitating communication, promoting professional development, and ensuring representation for the graduate students and postdocs.

"BTI provides an ideal environment for an organization like the PGS to flourish. As plant-based researchers at similar points in our careers, we have a lot in common," remarked Tom Bollenbach, a postdoc and the PGS chair. The PGS sponsors a variety of activities to stimulate collaborative efforts and discussions among BTI researchers. Invited speakers, happy hours with distinguished lecturers, and the Career Development and Career Perspectives seminar series all play a role in enhancing the BTI postgraduate experience.

How to recruit, train, and manage other scientists—not to mention how to manage a budget—are skills to which scientists transitioning into supervisory positions often have minimal exposure. The goal of the Career Development Series is to provide postdocs and graduate students with the aptitude to master these areas. "All researchers are trained in experimental science, but we also benefit from mentoring in other areas, such as how to write a grant proposal, how to present a seminar, and how to prepare a job application," Bollenbach commented. This past year, speakers for the Career Development Series focused on creating effective presentations, writing concisely and clearly, and conducting interviews.

Many career options outside of academia attract plant biologists; however, graduate students and postdocs often are unaware of the breadth of these alternatives. As part of the Career Perspectives Seminar Series, Karin Lohman, the acting director of the NIH Allergy and Infectious Disease Strategic Planning and Evaluation Branch and Freedom of Information Act Office, and Emily Heaton, manager of Energy Crop Product Development at Ceres, Inc., discussed careers in nontraditional areas, including policy and the corporate side of biotechnology companies.

Sarah Covshoff, a graduate student and coordinator of the Career Perspectives Series, said, "Support from BTI for this series is part of what makes BTI one of the best places to work. The PGS provides a wonderful forum to network with a broad spectrum of science professionals—this network is an invaluable resource for early career scientists." According to *The Scientist* magazine's Best Places to Work survey of postdocs (www.the-scientist.com), a cooperative, interactive atmosphere that encourages career development is integral to postdoc satisfaction.

Research Reports

Back in 1920, William Boyce Thompson hypothesized that world political stability would depend on the availability of adequate food, while population growth would create the need for a larger food supply. Over 85 years have passed since then, and political unrest brought on by famine and the ever-increasing world population has shown Thompson's hypotheses to be accurate. He believed that basic research in plant biology could address these challenges and improve human welfare. Research at BTI continues to carry out its founder's vision by addressing questions relating to plant physiology, disease resistance, plant-animal interactions, and nutritional quality, providing tangible benefits to society.

Gary Blissard

SCIENTIST, VICE PRESIDENT FOR RESEARCH

Adjunct Professor, Cornell University Department of Microbiology and Immunology and Department of Entomology

Viruses have a reputation for being dangerous organisms, but that doesn't preclude their utility. This is the case for baculoviruses. Lethal to many insect pests but harmless to humans and beneficial to some insects such as honeybees, baculoviruses have been used as a natural means to control predation of crops by insects. Gary Blissard is working to understand exactly how these viruses carry out their deadly mission.

The Blissard lab has determined that a protein on the outside of some baculoviruses, GP64, acts as a key that permits the virus to enter the insect cell, the first stage of infection. Antibodies are capable of blocking this action, making them useful tools in investigations of exactly which parts of the protein unlock the insect cell. By using antibodies specific to sections of GP64, Blissard's group is able to identify the portions of GP64 "neutralized" by the antibodies, preventing the virus from entering the cell.

Once the virus has gained entry, it must replicate itself by producing proteins that can be assembled into new viruses. The 150+ genes in the baculovirus genome must be turned on and off at appropriate times to correctly produce these building blocks. The Blissard lab is investigating the regulatory roles of various viral genes by disabling those that may be responsible for providing this guidance. Understanding the process by which baculoviruses infect insect cells could enhance their utility as natural insecticides.

In addition to biocontrol, baculoviruses have been widely used as "factories" to produce high levels of particular proteins—including a vaccine to prevent infection by human papilloma virus, a leading cause of cervical cancer. A key component of "baculovirus factories" is the insect cell line in which the virus lives. In collaboration with Emeritus Professor Robert Granados, Blissard's lab is generating new insect cell lines for high-level production of proteins, which will also be valuable in continued studies of baculovirus biology.

Tom Brutnell

ASSOCIATE SCIENTIST

Adjunct Associate Professor, Cornell University Department of Plant Biology and Department of Plant Breeding and Genetics

Tom Brutnell's research follows in the footsteps of Barbara McClintock, the famous Cornell geneticist and Nobel laureate who identified transposable elements (transposons) in maize (corn). A "jumping gene" is a fragment of DNA that can move from one place in the genome to another, often interfering with the functioning of the gene in which it lands. This can result in changes in the plant's appearance or alter other traits, making it possible to determine the role of the affected gene.

Brutnell's group is distributing several thousand *Ds* elements—a particular type of transposon—throughout the maize genome, creating a seed library with *Ds* elements that have hopped into thousands of genes. This invaluable resource has numerous applications and will be available to maize researchers around the world.

By using *Ds* to disable genes that are necessary for the production of cell walls, the Brutnell lab is investigating how this structure is synthesized in grasses such as maize. Because digestion of the cell wall is a time-consuming and expensive step in the production of cellulose-based biofuel, the development of maize varieties with altered cell-wall properties is a high priority. It offers the potential to alleviate pressing environmental concerns by increasing the production of renewable transportation fuel that may help decrease greenhouse-gas emissions.

Because maize is one of the most important crops in the world—over 720 million tons are grown annually, accounting for 15–20 percent of the total daily calories in more than 20 developing countries and serving as a primary feedstock in the United States—maize research offers many potential benefits. Along with applications to improve crop varieties, the knowledge gained may enhance efforts to engineer other agronomically important grasses, such as rice, sorghum, and switchgrass. Collaborations with scientists at Monsanto are accelerating the application of some of Brutnell's findings.

MAIZE OFFERS THE POTENTIAL TO ALLEVIATE PRESSING ENVIRONMENTAL CONCERNS BY INCREASING THE PRODUCTION OF RENEWABLE TRANSPORTATION FUEL.

Zhangjun Fei

ASSISTANT RESEARCH SCIENTIST

Although counting from one to one hundred billion would take an average person at least four millennia, it has taken only a quarter century to collect the information now found in the worldwide database of DNA sequences—over 130 billion nucleotides and growing.

Scientists first developed a technique for rapidly sequencing DNA in 1977. In the past 30 years, new technologies have dramatically altered the research landscape, resulting in an unprecedented flow of sequence and gene-expression information. The proliferation of these massive datasets has also posed difficulties, however, particularly in how to organize and interpret them. Addressing these issues is the role of bioinformatics, a relatively new and rapidly growing field at the interface of biology and computer science.

Bioinformaticists integrate the comprehensive profiles of an organism's biology at many levels—including DNA sequence, gene expression, protein occurrence, and metabolite occurrence. Zhangjun Fei develops the associated computational tools and resources, helping researchers understand how genes work together to form functioning cells and organisms. Fei's particular interest is in investigating changes in gene expression related to fruit development, ripening, and nutrition.

Collaborating with the Giovannoni lab, Fei has developed a database that contains information on the expression of thousands of tomato genes. As a central repository for all tomato gene expression data, this database contains information from diverse plant tissues at different stages of development. Fei has developed analytical and data-mining tools for efficient extraction of biological information from this database. The long-term goals are to further our understanding of plant physiology and development and to identify novel regulators that control important traits, such as fruit nutrition and flavor quality.

Jim Giovannoni

SCIENTIST

Plant Molecular Biologist at the USDA-ARS Plant, Soil and Nutrition Laboratory

Adjunct Professor, Cornell University Department of Plant Biology

Jim Giovannoni is trying to make it impossible to tell the difference between summer and winter—at least by the flavor of tomatoes.

Fruit flavor, appearance, texture, and nutrition are enhanced by ripening, a process that is naturally regulated by the plant hormone ethylene. However, over-ripening leads to losses after harvest as well as decreased fruit quality. To reduce spoilage, growers often initiate ripening during shipping by exposing immature tomatoes to ethylene. But, as consumers of these red winter tomatoes know well, their flavor is a poor reflection of that of vine-ripened fruit. Ensuring optimal taste qualities in winter-grown tomatoes would have significant consumer benefits.

Mutant tomatoes with a reduced sensitivity to ethylene do not ripen properly, but until recently this phenomenon was not fully understood. Insight came when Giovannoni's lab discovered a protein involved in the tomato ethylene response. They isolated the chromosomal regions responsible for producing unripe tomatoes in two mutants and discovered that both have identical alterations in the gene *Gr,* which stands for Green-ripe. *Gr* is particularly interesting; it is evolutionarily conserved but its biochemical function is unknown. Further investigations of *Gr* promise to open new insights into how ethylene regulates ripening and may ultimately be useful for reducing the impact of ethylene on ripe fruit. If all goes well, before long the tomatoes that we purchase in winter will be as flavorful and fresh as the homegrown summer product.

The implications of research in the Giovannoni lab may someday tickle the palates of lovers of many other fruits—peppers and melons for example. Giovannoni's goals are to identify the genes that regulate ripening across a range of species and to determine how they coordinate ripening events. The "fruits" of this exciting research will be myriad delicious fruits that we will all be able to enjoy regardless of the time of year. Sometimes Mother Nature just needs a little help from science.

IF ALL GOES WELL, BEFORE LONG THE TOMATOES THAT WE PURCHASE IN WINTER WILL BE AS FLAVORFUL AND FRESH AS THE HOMEGROWN SUMMER PRODUCT.

Maria Harrison

SCIENTIST

Adjunct Professor, Cornell University Department of Plant Pathology

Toxic algal blooms, severe reductions in water quality, a disruption of normal ecosystem functioning, loss of biodiversity: these are only some of the negative consequences of excess nutrients in bodies of water. Phosphorus is often added to soils as a fertilizer, but run-off from watersheds can cause overgrowths of algae, setting off a problematic chain reaction.

Close relationships between plants and certain fungi mitigate this problem. Arbuscular mycorrhizal fungi form symbiotic associations with over 80 percent of flowering plants, including the grass of your lawn. The relationship develops in the plants' roots—the fungus moves into the cortical cells to obtain carbon, which it cannot otherwise acquire. In turn, the fungus transfers phosphorus from the soil to the plant.

Despite the widespread occurrence of this relationship, the mechanisms driving phosphate and carbon transfer are largely unknown. Recent research in Maria Harrison's lab has exposed the vital importance of phosphorus transfer in the maintenance of the symbiotic relationship—in fact, the plant will terminate its association with the fungus without continual delivery of phosphorus.

In a search to discover how the fungus transfers phosphorus, members of Harrison's lab identified MtPT4, a protein they believed to be essential for transport. Using a technique known as RNA interference, they disrupted MtPT4 function; the specialized structures that deliver phosphorus were lost prematurely, and the fungus was no longer able to proliferate inside the root. In other words, the plant refused to host a guest that failed to bring a gift.

Harrison's long-term goal is to understand the mechanisms underlying the development of this essential relationship and phosphorus transfer between the symbionts. Additional insight could benefit efforts to engineer crops with reduced reliance on fertilizers.

Georg Jander

ASSISTANT SCIENTIST

Adjunct Assistant Professor, Cornell University Department of Plant Biology

When mosquitoes come out in summer, humans can move indoors to avoid being bitten. Plants cannot avoid attacks by insects, but have evolved cunning means of defense by producing deterrent compounds.

Georg Jander is interested in the process by which *Arabidopsis* fends off attackers. For some unlucky insects, the action of crunching on a leaf releases the enzyme myrosinase, which cleaves chemicals known as glucosinolates into smaller molecules. Although some glucosinolates may thwart herbivory without being cleaved by myrosinase, it is thought that the primary repellent molecules are products of the breakdown of glucosinolates. In other words, the plant takes advantage of the insect's snacking.

More fortunate insects, such as aphids, manage to avoid releasing myrosinase while feeding. Not to be outdone, the plant manufactures glucosinolates that break down even without myrosinase, thereby producing aphid-repellent molecules. Members of the Jander lab have identified specific glucosinolates produced in response to aphid feeding and have determined which act as deterrents. Because this defensive response is triggered by particular components of the aphid's saliva, the Jander lab is now working to separate these components and determine which provoke a response.

To complicate matters, not all glucosinolates deter insects. Other research in the Jander lab has demonstrated that butterflies and moths lay fewer eggs on mutant *Arabidopsis* plants that are unable to produce certain glucosinolates. This suggests that glucosinolate breakdown products may actually attract egg-laying female butterflies and moths. Understanding the nuances of these interactions is a complex yet inviting problem.

Despite plants' means of self-protection and humans' use of a variety of practices to control insects that feed on plants, yield losses from predation are estimated to average more than 15 percent for the major food and field crops worldwide. Untangling these multifaceted plant-insect interactions may help to mitigate crop loss, thereby increasing production without increasing acreage.

Dan Klessig

SCIENTIST

Adjunct Professor, Cornell University Department of Plant Pathology

For the government's Emergency Alert System to function properly, there needs to be agreement about what constitutes an emergency, who can initiate an alert, how the alert will be spread, and how to recognize that alert. In an analogous way, when one part of a plant is under attack, a complex system warns other parts of impending danger.

Dan Klessig is learning how a plant initiates this response to a viral attack. Previous research in Klessig's lab identified salicylic acid (SA) and nitric oxide (NO) as two important signals the plant uses to activate a defense response. Current research in the Klessig lab is focused on how SA and NO are integrated into the response pathway.

One signaling component is SABP2, a protein known to interact with SA. Members of the Klessig lab silenced the gene *SABP2* to determine its role.

Greg Martin

BOYCE SCHULZE DOWNEY SCIENTIST

Professor, Cornell University Department of Plant Pathology

There are many examples of mimicry in the natural world—tasty butterfly species resemble toxic ones, flowers that don't produce nectar resemble those that do to lure pollinators, some turtles have tongues that resemble worms to lure prey. Not to be outdone, bacteria have joined the costume party. Research in Greg Martin's lab has discovered multiple instances of mimicry in bacteria.

The Martin lab studies the molecular basis of the immunity and susceptibility of tomato to the bacterial pathogen *Pseudomonas syringae* pv. *tomato*. When *Pseudomonas* secretes the proteins AvrPto or AvrPtoB into a resistant plant cell, the cell's Pto protein recognizes the foreign invaders and launches a defense response. Tomatoes that do not produce Pto are susceptible to *Pseudomonas* and, in this case, AvrPto and AvrPtoB act to suppress other general plant defense responses.

Members of the Martin lab have been trying to determine how AvrPto works. Clues to its function have come from observations that the plant's own enzymes modify AvrPto by attaching phosphates to it. For unknown reasons, this increases the virulence of AvrPto and, they believe, functions as an initial "activation" step that is necessary for subsequent interaction with components of the plant cell. Apparently, this bacterial protein has successfully mimicked plant enzymes so that the plant unwittingly alters the protein and increases its virulence.

The Martin lab discovered another example of mimicry. AvrPtoB was found to resemble structurally a plant enzyme known as an E3 ubiquitin ligase, which initiates a reaction that attaches a ubiquitin molecule to other proteins, causing them to be targeted for degradation. Through this mechanism, AvrPtoB somehow suppresses localized cell death and thus permits the infection to spread. By helping to elucidate fundamental aspects of bacterial infection and the associated plant response, this research will allow scientists to develop more effective and sustainable disease-control methods.

Peter Moffett

ASSISTANT SCIENTIST

Adjunct Assistant Professor, Cornell University Department of Plant Pathology

Unlike animals, plants do not have an adaptive immune system with agents like white blood cells circulating to destroy alien intruders. However, over hundreds of millions of years of evolution, plants have developed a multitude of highly variable disease resistance genes that give them both diversity and specificity in neutralizing invading pathogens.

These disease-resistance proteins allow the plant to resist specific pathogens, as long as the pathogen displays a matching avirulence protein. Peter Moffett's goal is to understand how disease-resistance proteins recognize avirulence proteins and how this recognition elicits a plant response.

One approach is to identify new plant proteins that interact with the disease-resistance protein Rx and either co-operate in pathogen recognition or help to initiate a defense response. The Moffett lab succeeded in identifying one such player, RanGAP, which acts as an accessory in inducing an anti-viral response. They found that RanGAP also interacts with another protein, GPA2, which confers resistance to potato pale cyst nematode, a pathogen that has recently been found for the first time in the United States. Because these nematodes produce a protein thought to interact with RanGAP, the Moffett lab decided to test whether GPA2 would also recognize this nematode protein. When they expressed both GPA2 and the nematode protein in a tobacco leaf, the plant responded by killing off those cells.

This novel nematode protein that interacts with GPA2 is the first avirulence protein to be identified from a plant-parasitic nematode. Closely related proteins are present in other nematodes, which has important implications for studies of nematode virulence and population structures, as well as for developing and deploying nematode-resistant plants.

They found that SABP2 plays a critical role in systemic acquired resistance, a form of immunity where the plant mounts a defensive response to the virus in uninfected parts of the plant, providing resistance against secondary attacks. By using a novel approach involving the introduction of a synthetic version of SABP2, the Klessig lab confirmed that the response they were seeing when silencing *SABP2* (loss of systemic acquired resistance) was actually due to turning off *SABP2*, rather than an unintentional side-effect of the silencing technique.

Another protein involved in this pathway is aconitase, known to be inhibited by both SA and NO. To study its role, the Klessig lab, with assistance from the Martin lab, silenced the aconitase gene in both *Arabidopsis* and tobacco. These aconitase-deficient plants showed increased tolerance to oxidative stress and patches of cell death, a plant's means of preventing a virus from spreading, demonstrating the important role of aconitase in plants' resistance.

Although plants do have some defenses against viruses, viral diseases can cause yield reductions of up to 100 percent, leading to financial loss and food insecurity. By understanding how a plant mounts a defense response, scientists may be able to manipulate the defense mechanisms and give plants a little help so they won't have to fight the battle alone.

David Stern

SCIENTIST, PRESIDENT

Adjunct Professor, Cornell University Department of Plant Biology

Photosynthesis may be considered the most important biological process. Carbon dioxide fixation directly or indirectly produces most food consumed on earth, while simultaneously mitigating climate change through CO_2 sequestration. Energy stored in firewood, fossil fuels, and even natural gas produced through anaerobic decay of organic material, ultimately had its source in organisms that transformed light energy via the photosynthetic process.

As the site of photosynthesis as well as of other metabolic pathways, chloroplasts play numerous essential roles in plant development and responses to environmental stimuli. By studying gene regulation under normal and stress conditions, David Stern investigates various processes in the chloroplast.

Carbon fixation requires a large continual supply of phosphorus. Since soils often do not contain adequate amounts of phosphorus in a form that is readily accessible, plants have adapted in multiple ways, including scavenging both outside the plant and within it, reallocating phosphorus from organs where it is less essential. Stern's lab has studied the role of polynucleotide phosphorylase, or PNPase, a chloroplast enzyme known to play a role in RNA degradation, in cells exposed to limited phosphorus. In normal cells starved for phosphorus, they found that PNPase expression is decreased and chloroplast RNA accumulates.

Under the same conditions, cells that have been modified to not produce PNPase did not display reduced chloroplast RNA levels, and the cells began to die after one day. This suggests that PNPase is required for cells to acclimate to low phosphorus. In contrast to RNA, chloroplast DNA levels declined significantly under phosphorus deprivation, perhaps due to phosphorus being scavenged from DNA.

Stern hypothesizes that the newly discovered role of PNPase in conditions of limiting phosphorus may be even more important than the previously known role of participating in RNA degradation. PNPase may help maintain metabolite balance in the chloroplast, and in the cell as a whole. These dual functions of PNPase add it to a growing list of enzymes that have evolved multiple and sometimes varied functions.

THE NEXT TIME YOU SEE AN ORANGE POTATO IN THE GROCERY STORE, IT MAY NOT BE A SWEET POTATO.

Joyce Van Eck

SENIOR RESEARCH ASSOCIATE

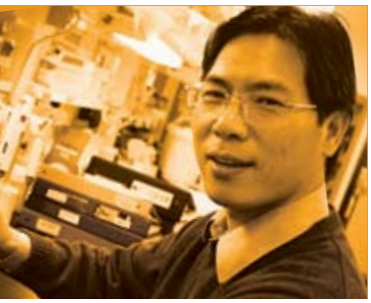
The next time you see an orange potato in the grocery store, it may not be a sweet potato.

Recent research in Joyce Van Eck's lab has focused on increasing beta-carotene content in potato. This orange pigment is a precursor to vitamin A, which is necessary for proper eyesight and functioning of the immune system. The World Health Organization estimates that 100 to 140 million children under the age of five may have dangerously low vitamin-A levels, greatly increasing the incidence of disease and death. Increasing beta-carotene content in staple foods will help to reduce this vitamin deficiency and its tragic consequences.

Van Eck has successfully used two different methods to create high-beta-carotene potatoes. In one approach, the Van Eck lab used RNA interference to silence the gene the product of which converts beta-carotene to zeaxanthin, another type of carotenoid. As a result, more carotenoids were "trapped" into accumulating as beta-carotene. Potatoes with the silenced gene contained 3–300 µg of beta-carotene per 100 g fresh weight, in contrast to the trace amounts found in conventional potatoes.

In collaboration with Li Li at the U.S. Department of Agriculture, Van Eck tested another approach, which was to insert a variant of the orange gene, *Or*, from orange cauliflower into potato. This variant arose through a spontaneous mutation and is one of only a few mutations known to cause carotenoid accumulation in tissues not ordinarily containing the pigment. Indeed, expression of *Or* led to increased beta-carotene in transgenic potatoes, demonstrating that natural mutations can be used to improve crop nutrient quality.

These new potato lines are now being crossed with conventional lines to integrate *Or*—soon we may have varieties of cultivated potatoes that are both delicious and more nutritious.



Haiyang Wang

ASSISTANT SCIENTIST

Adjunct Assistant Professor, Cornell University Department of Plant Biology

Without light, almost all plant life, and many animal species, would perish. Light not only provides energy to drive photosynthesis, but also is a signal that plants utilize to sense their environment. Color, intensity, direction, and duration influence when, how fast, how tall, and in what direction plants sprout and when they flower. Although these functions have significant consequences for agriculture, scientists are only just beginning to understand how plants perceive and respond to light.

When a specialized plant protein called a photoreceptor is struck by a photon, it passes a message to another molecule, which relays it to another, and so on. This relay of light information leads to altered gene expression and adaptive plant growth and development.

Phytochromes are photoreceptors that sense red and far-red light. Because plants absorb red light but transmit far-red light, the latter is enriched under shade canopies. By detecting a lower ratio of red to far-red light under the canopy, plants sense competition from neighboring vegetation. In an attempt to out-compete their neighbors for light, they elongate their stems and expand their leaves. Understanding how this process is regulated in plants may help in designing new means of crop improvement.

Haiyang Wang's lab studies the role of two novel, closely related proteins, FHY3 and FAR1, in the regulation of plant development by far-red light, which is specifically perceived by the phytochrome A (phyA) photoreceptor. The Wang lab has demonstrated that both proteins are capable of directly binding DNAs and activating the expression of neighboring genes. He is searching the genome to find genes directly regulated by FHY3 and FAR1 and studying the roles of these "downstream" genes in mediating phyA signaling and plant development under far-red light.

SCIENTISTS ARE ONLY JUST BEGINNING TO UNDERSTAND HOW PLANTS PERCEIVE AND RESPOND TO LIGHT.

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Active Emeriti and Retired Scientists

Curiosity, a desire to improve the world, and a passion for sharing knowledge with others—scientists don't relinquish those characteristics when they retire.

Robert Granados (Charles E. Palm Scientist Emeritus) traveled to China in August to attend the annual meeting of the Society for Invertebrate Pathology. At the meeting in Wuhan, Granados was recognized for his outstanding achievements in research and service to the society by being named an honorary member. At Qingdao Agricultural University, he was appointed honorary visiting professor. Following his seminar to the Entomology faculty and students, University Vice President Dai Hong Yi presented Granados with a certificate of appointment. Granados has continued cell culture research with Gary Blissard and Guoxun Li, a visiting professor from Qingdao. He also has kept busy in the BTI Intellectual Property Office.

In April, **Robert Kohut** attended the 38th Annual Air Pollution Workshop in Charlottesville, VA, where he received the "Golden Nut" award. The award recognized his 30 years of fieldwork and other research on the effects of air pollution on plants. At the workshop, he made two presentations on his recent work for the U.S. National Park Service: "Assessment of the Risk of Foliar Ozone Injury on Plants in 270 National Parks" and "The Development of a Handbook for Assessing Foliar Ozone Injury on Plants in the Field." These documents help the Park Service address concerns about ozone impacts in the national parks.

Carl Leopold (William H. Crocker Scientist Emeritus) has maintained an active research program and recently received a Podell Grant from the Cornell Association of Professors Emeriti. Leopold and collaborator Mark Jaffe will be studying root tropism and contractile roots—specialized roots at the base of bulbs that can shrink vertically during drought to position the plant at an appropriate level below ground. Leopold has continued to give talks on environmental issues to a wide audience. In February, he was invited to give two graduate seminars on ethical relations with nature for the Department of Religion and Ethics at the University of North Texas. Leopold also delivered two seminars to graduate students in the Natural Resources Department at Cornell regarding ethical relationships with natural resources. In November, he served as a panelist in a discussion concerning the interrelationships of hunting, wildlife, and conservation at the Rockwell Museum of Western Art in Corning, NY.

In September, **Alan Renwick** was invited to speak at the First International Conference on Glucosinolates, at the Max Planck Institute for Chemical Ecology in Jena, Germany. This past year, Renwick published two articles on various plant compounds and their effects on feeding and egg-laying behaviors of two species of moths. He conducted numerous peer reviews, principally for the *Journal of Chemical Ecology.*

Richard Staples (George L. McNew Scientist Emeritus) recently published an article on transient gene expression and mutagenesis of the fungus that causes leaf rust in wheat. Staples has continued to serve on the editorial board of *FEMS Microbiology Letters.* As the mini-reviews editor, he solicits and edits about 20 manuscripts per year on nonmedical aspects of fungi and bacteria.

Leonard Weinstein (William B. Thompson Scientist Emeritus) has continued his work as co-technical director of an external monitoring program for a new aluminum smelter in Iceland. The purpose of the study is to gauge effects of fluoride emissions on plant and animal life. After two years of baseline monitoring, the smelter will begin operating in spring 2007 and changes at the ecological level will be studied.

Alan Wood presented a plenary address at the 18th annual meeting of the National Agricultural Biotechnology Council, at Cornell in June 2006. The lecture was entitled, "Agricultural Research: Beyond Food and Fiber." During the past year, he spent considerable time preparing grant reviews for the U.S. Department of Agriculture and Maryland Technology Development Corporation and personnel reviews for the U.S. Environmental Protection Agency. As a member of the congressionally mandated USDA Research, Education, and Economics Task Force, Wood has continued to promote a National Institute for Food and Agriculture. He also spent time at Mississippi State University planning the operations of the Life Sciences and Biotechnology Institute and assisting in the search for a new director.

Photographer: Sheryl Sinkow Additional photography: Lucy Pola, Maria Harrison, Roger Hangarter, Elizabeth Fox, Fred Sack, Shawna Williams, Jim Burns, Chicago Botanic Garden, Marceline Vandewater, Phil Lowe, John Ellis

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2006 Grants

BTI Principal Investigator	Grant Title	Sponsor	Collaborator	Amount
Tom Brutnell	Transposable Elements in Rice: A Whole Genome Approach	University of Georgia	NSF	$72,818
Jim Giovannoni	Functional Genomics of Melon for Improved Fruit Quality	BARD	Volcani Institute	$85,000
Jim Giovannoni Joyce Van Eck	TRPGR: U.S. Contribution to the International Solanaceae Genome Effort: Global Bioinformatics and Sequencing of Chromosomes 1, 10 and 11	NSF	Cornell University Colorado State University	$1,800,000
Maria Harrison Greg Martin	Acquisition of a Fluorescence Stereoscope and Laser Scanning Confocal Microscope for Spectral Imaging of Plant Cells	NSF		$554,342
Maria Harrison Georg Jander Peter Moffett David Stern	Plant Based, Health Focused Research—2006	Triad Foundation, Inc.		$250,000
Georg Jander	Genetic, Genomic, and Biochemical Analysis of Arabidopsis Threonine Aldolase and Associated Molecular Metabolic Networks	BARD	Weizmann Institute	$145,000
Elizabeth Fox Deanna Grantz	*sLowlife*	Helen Graham Charitable Foundation		$7,500
Dan Klessig	Characterization of the High Affinity Salicylic Acid-Binding Protein 2 in Plant Disease Resistance	NSF		$23,891
Greg Martin	GEPR: Exploiting Tomato Genomics Resources to Investigate Basal Plant Defenses Against Pathogens	NSF	Cornell University	$1,124,929
Greg Martin	Role of Bacterial Virulence Proteins in Plant Cell Death	NIH		$872,550
Greg Martin	Role of MAPKKKa-Mediated Cell Death in Plant Disease Resistance and Susceptibility	NSF-REU	Wabash College	$12,500
Greg Martin	Role of an AvrPto-Dependent Pto-Interacting Protein, Adi3, in the Host Response to *Pseudomonas*	USDA	Texas A & M University	$399,560
David Stern	Chloroplast Ribonucleases at the Crossroads of Phosphate Limitation Response and RNA Metabolism: RNase E and Polynucleotide Phosphorylase	Binational Science Foundation	Technion, Israel Institute of Technology	$96,000
David Stern Gary Blissard	Insect Cyborg Sentinels	DARPA	Cornell University Pennsylvania State University Universidad de Valparaiso, Chile	$8,454,051
David Stern	American Society of Plant Biologists 2006 Education Foundation Grant Award	American Society of Plant Biologists		$9,975
Joyce Van Eck	Enhancement of Beta-Carotene in Potato	Helen Graham Charitable Foundation		$10,000

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Research	$8,252,000	69%
Administration	1,803,000	15%
Research support services	789,000	7%
Equipment & facility	643,000	5%
Non-research	391,000	3%
Fund-raising	103,000	1%
	$11,981,000	**100%**

SOURCES OF FUNDS

U.S. Government	$5,402,000	43%
Institute endowment	3,652,000	29%
New York State	1,683,000	14%
Unrestricted revenues	1,143,000	9%
Other private sources	486,000	4%
Foundations	98,000	1%
	$12,464,000	**100%**

83rd BTI Annual Report

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