# The Miami MIST

DEPARTMENT OF BOTANY • MIAMI UNIVERSITY • OXFORD, OHIO 45056

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## LETTER FROM THE CHAIR

Dear alumni and friends, I extend my greetings as the new Chair of the Botany Department, a position that I started in July 2008. As you know, the university and our department have faced very challenging times related to the recent economic crisis. A number of changes have been instituted, and our faculty have been working even harder in their multifaceted approaches to teaching and research.

One of the department's priorities in the past year has been curriculum reform and other initiatives to update undergraduate training. We have a number of new exciting courses, including offerings in medicinal botany and evolutionary biology. The department is working on a new minor in plant biotechnology to complement our B.S. with emphasis in biotechnology. I am very excited about these initiatives and believe that we will continue to offer one of the best botany programs in the country.

Our strengths are based on the excellent faculty and students in the department. You can read about some of our achievements in this newsletter. I also encourage you to visit our home page at http://www.cas.muohio.edu/botany/ and look at our news section which is continually updated. Our graduate students continue to excel and have received a number of national-level awards. In addition, several of our graduating seniors received recognition from the Botanical Society of America by their receipt of Young Botanist Awards.

Last summer a large number of graduate students completed their degrees (both M.S. and Ph.D.). I served on several of the committees and was delighted with the high quality of the work. A testament to the success of our graduate students is the fine placement of this group including post-doctoral positions at UC-Davis and -Riverside, and Harvard, as well as good jobs in industry.

Thank you for your continuing interest in the Botany Department at Miami University. I hope you enjoy this newsletter.

Best wishes,

John Z. Kiss

**Winter view from the Chair's Office**

If you are interested in supporting the department's efforts to enhance educational and research opportunities, please contact the Foundation Office at (513) 529-1263, or send your contributions to: Botany Department c/o Evan Lichtenstein, Miami University Division of University Advancement, 725 E. Chestnut St., Oxford, OH 45056

## Departmental Awards & Alumni News

- Aaron Kennedy, botany doctoral student, received the 2008 Richard and Minnie Windler Award for the best paper in plant systematics published in *Castanea*. Kennedy's paper, co-authored with Gary Walker, Professor of Biology at Appalachian State University, was titled, "The Population Genetic Structure of the Showy Lady's-Slipper Orchid (*Cypripedium reginae* Walter) in its Glaciated and Unglaciated Ranges." This marks the third time in a row that Miami graduate students have won the Windler Award: Matthew Sewell won in 2007, and Kerry Heafner in 2006.

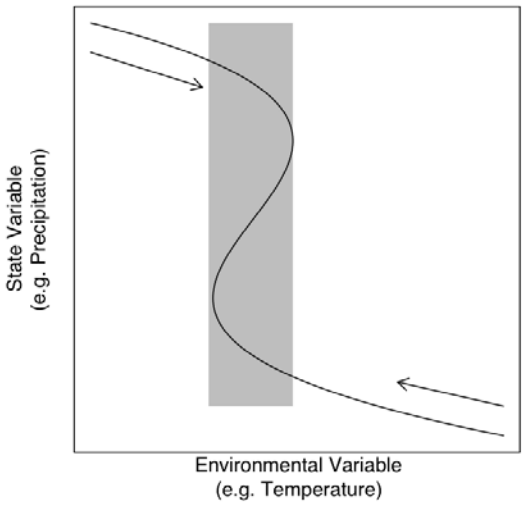
- Melanie Link-Perez, doctoral student in botany, received the Edgar T. Wherry Award at the annual meeting of the Botanical Society of America for her paper, "Toward a Redefinition of *Adiantopsis* Fee (Pteridaceae)." Link-Perez is conducting her dissertation research with adviser R. James Hickey (botany).

***Adiantopsis radiata* in Argentina**

- Bryan Endress (Ph.D. 2002) was appointed Associate Director of Conservation and Research for Endangered Species (CRES), the conservation research program of the Zoological Society of San Diego. Bryan also heads CRES Applied Plant Ecology Division. Dr. Endress was a doctoral student with David L. Gorchov.

- W. Hardy Eshbaugh, Professor Emeritus of Botany, received the Peter H. Raven Award for his outreach in the areas of public education and conservation. Presented by the American Society of Plant Taxonomists during its conference this summer, the award recognizes a plant systematist for exceptional outreach efforts to non-scientists. Eshbaugh was a member of Miami's faculty from 1967-98, including positions as chair of the department and director of Miami's W.S. Turrell Herbarium.

## New Book on Theoretical Ecology by Hank Stevens (Associate Professor of Botany)




Hank Stevens' new book "A Primer of Ecology with R" (Springer-Verlag, 405 pp.) will be published in July 2009. Ecology is more quantitative and theory-driven than ever before, and this book combines an introduction to the major theoretical concepts in general ecology with a cutting edge Open Source tool, the R programming language. It combines the best attributes of other introductions to theoretical ecology by covering a wide range of topics, and is successful in leading readers – even those with little prior knowledge of the field – toward a relatively sophisticated level of inquiry. It also uses the Open Source programming language R to illustrate each topic.

## Modernizing the Undergraduate Curriculum

Two Department of Botany professors, Drs. Elisabeth Schussler and Jim Hickey, and graduate student Melanie Link-Perez, spearheaded efforts in 2008 to modernize the first semester Introductory Biology Laboratory experience at Miami. As part of a team awarded a Course, Curriculum, and Laboratory Improvement grant from the National Science Foundation, and a Top 25 grant from Miami University, they re-wrote and piloted new biology labs that were consistent with the principles of scientific inquiry. For instance, students were given three fungal species and challenged to investigate competition by growing the species separately and together. Students also used C-fern plants to probe the role of hormones in gametophyte sex development in this species.

The new labs were performed by 670 students in fall 2008, via an experimental design that varied two pedagogical treatments in tandem. In some labs, students were told how to do the experiments, while in others they designed the experiments on their own. In some of the labs, teaching assistants led students in discussions on the nature of science, while in others they did not. The researchers hypothesized that students would gain more content, process, and nature of science understanding when they designed their own labs and discussed the nature of science. Preliminary data are being analyzed, and early results suggest that students who designed their own experiments out-performed other students on measures of content understanding and were more likely to self-identify gains in scientific process skills as a result of the course. All students, regardless of treatment, had a more appropriate understanding of the nature of science on post-semester assessments than they did on pre-semester assessments. Data analysis will continue through the spring to identify additional project outcomes and to choose and revise one type of lab to implement in fall 2009.

## Tracking an Invader

A team of investigators is making progress on understanding the invasion of an exotic shrub into deciduous forest fragments with support from a U.S. Department of Agriculture grant to David Gorchov (Botany), Mary Henry (Geography), and Oscar Rocha (Kent State University) entitled, "Effect of landscape structure on invasion dynamics of the invasive shrub *Lonicera maackii*."

*Lonicera maackii*, Amur honeysuckle, is one of several Eurasian bush honeysuckles that invade forests in the eastern and central United States, and is one of the most problematic forest invaders in Ohio. One important finding of the study is that the cover of *L. maackii* in forest understory can be estimated using satellite imagery, taking advantage of this shrub's extended leaf phenology. This was demonstrated in the Master's thesis research of Bryan Wilfong, a student in the Institute of Environmental Science (IES) program advised by Drs. Gorchov and Henry. Bryan found that cover of *L. maackii* in woodlots in Preble and Darke County, correlated well with Landsat satellite images acquired in November, after canopy leaf fall, but before honeysuckle leaf drop. The correlation was improved by subtracting imaging data from a Landsat image obtained in January. This difference explained 75% of the variation in *L. maackii* cover among 35 woodlots. The next challenge for the researchers is to improve their ability to predict *L. maackii* cover with remote-sensed imagery, through the use of data from other satellite platforms with greater spatial or spectral resolution, or data from other seasons. This is one of the experimental objectives of doctoral student Steven Castellano, working under the mentorship of Dr. Gorchov. Ultimately, the team hopes to reconstruct the historical pattern of *L. maackii* invasion using archived satellite imagery, and to use this to investigate which landscape features promote or impede its spread.

Meanwhile, progress is being made on another objective of the study, determining the source of new invasions. Gorchov and colleagues are studying whether honeysuckle shrubs planted in residential landscaping are responsible for new invasions in woodlots. It is possible that shrubs in other woodlots are the actual parents. The importance of long-distance seed dispersal is another factor that they are studying. Analysis of genetic markers is one of the approaches that they have employed. If potential parent populations are

sufficiently distinctive genetically, the genotypes of the first plants to colonize a site will reveal the most likely source population. Dr. Rocha has developed microsatellite marker loci for *L. maackii* and found substantial polymorphisms. His lab has found considerable variation among older, established populations that border the primary study area in Darke County, where woodlots have only recently been invaded. These findings suggest that they will be able to determine, with some confidence, the source population, of each colonization.

This research will advance our understanding of the processes driving invasion, but will also be of practical value to controlling this invasion. For example, the researchers hope to be able to predict which woodlots are at greatest risk of invasion, so that search-and-destroy missions can be optimized.

## The Search for the "Wild" Papaya

Papaya – either you think it is the ambrosia of the gods or you think it tastes like dirty feet. Regardless of your tastes, though, there are few model systems that are better for studying the genetics and evolution of plant sex chromosomes. That's right, the nuclei of papaya cells are either XX (if the plant is a female), or XY (if it's a male).

Dr. Richard Moore and his students, Jennifer Rieger and Laura Weingartner, are using papaya as a model for studying the early events in sex chromosome evolution. Papaya sex chromosomes are unique in that they appeared on the scene a mere 1 to 2 million years ago, quite young if you compare to human sex chromosomes that are on the order of 175-200 million years old! This makes papaya an excellent model for studying the early events in sex chromosome evolution.

The problem is, if you are going to study the evolutionary history of these chromosomes, you need to sample DNA sequences from a broad range of papaya individuals growing in their native habitat. So, in the summer of 2008, Dr. Moore and Ms. Rieger, along with their collaborator, Dr. Oscar Rocha from Kent State, traveled to Costa Rica, where the plant is thought to have originated, in search of the "wild" papaya.

**Jennifer Rieger holding leaf from wild papaya in Costa Rica**

The three explorers braved the wilds of Costa Rica in search of the elusive papaya plant. Actually, they didn't have to stray too far because it is a pioneer species and grows in disturbed habitats, including roadsides. But while most of the hunting involved scanning the vegetation while driving 30 km/hr, there were still many trials to endure. Dr. Rocha stepped on an ant nest at the base of one papaya, inciting the little devils to swarm up his legs and forcing him to remove his pants. While Ms. Rieger carefully recording GPS coordinates of one papaya, she was thrilled to learn that she had been standing one foot away from a Fer-de-lance, the most deadly viper in Central America. And, Dr. Moore endured burn-like lesions on his hands due to extensive contact with the milky sap from the papaya fruit and leaves … which happen to contain an enzyme commonly used as a meat tenderizer.

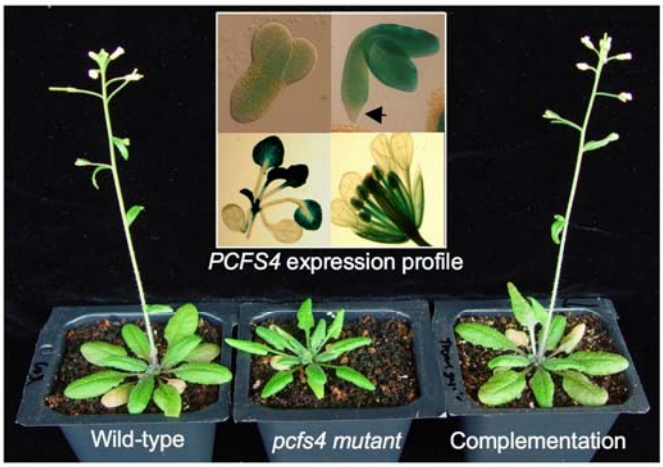
Despite the trials and tribulations, the trip was a success, and leaves from more than 200 plants were collected from the west and east coasts of Costa Rica. Now, the explorers are busy analyzing the DNA sequences from these individuals in the hope of learning the secrets of the formation and evolution of the sex chromosomes of this important crop plant.

## Systems approach to plant mRNA polyadenylation mechanisms

Messenger RNA polyadenylation is increasingly recognized as another hub for eukaryotic gene expression regulation. Significant progress in the

understanding of plant mRNA polyadenylation [poly(A)] has been made over the last few years, thanks in part of the contribution of Dr. Q. Quinn Li who has been using systems biology approaches in his research at Miami.

The location of a poly(A) tail of a RNA transcript marks its end. This position is predetermined by a set of RNA sequence elements called poly(A) signals. Using bioinformatics tools, the Li lab first identified multiple poly(A) sites from the sequenced plant and algal genomes, then compiled a complete set of signals that had been defined previously. This large-scale analysis resulted in the discovery of a new element. Using this signal information, in collaboration with computer scientists, they also built models to predict poly(A) sites to find alternative polyadenylation signals.




Mutation of polyadenylation factor PCFS4 caused flowering time delay due to differential alternative polyadenylation of *FLC* gene. (*Xing et al, Plant Journal 2008.*)

The seemingly simple process of cleavage and polyadenylation requires about 25 protein factors. Funded by a 4-year grant from National Science Foundation's Arabidopsis 2010 Program, and a new NSF grant, the Li lab, with collaborator Dr. Art Hunt, has systematically studied each predicted gene and their corresponding polyadenylation-related proteins, and authenticated their functions by their association with functional protein complexes. In the meantime, genetic studies revealed that some of these genes and their paralogs may have rather specific effects on gene expression regulation in plant gametophyte, embryonic and apical meristem development, flowering time control, and stress responses. Recently, the Li lab has made significant progress toward developing an *in vitro* assay system for plant mRNA cleavage and polyadenylation. Numerous attempts by a generation of students and postdocs failed to produce such an assay, until a protein over-expression in an *Arabidopsis* cell culture was used. With this new tool, a number of longstanding questions can now be addressed.

Powered by these systems biology tools, including bioinformatics, genetics and biochemistry, the Li lab has been highly productive with eight papers published during 2008 in journals including *Genetics, Nucleic Acid Research, Plant Journal,* and *PloS One*.

## Bioinformatics Research

Dr. Chun Liang's bioinformatics lab has been focusing on research and education in computational biology since its inception in fall 2005. Chun has trained nine undergraduate students in bioinformatics, and he is currently supervising Ph.D. and M.S. students. The lab group has been active in developing bioinformatics software tools, building biological databases, and students are using these approaches to study plant genomics, proteomics, and metabolomics.

The Liang lab's first bioinformatics software package is called ***WebTraceMiner***, a public web service for processing and mining Expressed Sequence Tag (EST) sequence data. The investigators introduced a new concept to EST data analyses, called "EST terminus." This is a set of diagnostic sequence elements, or features detected in raw EST DNA trace files, that delineate cDNA insert termini/ends, and therefore 3'/5' ends of mRNA transcripts. ***WebTraceMiner*** is the first bioinformatics tool capable of extracting the directional, positional, and structural information of cDNA termini from enormous amounts of EST data. The significance of this work lies in the development of a novel bioinformatics protocol for the processing (or reprocessing) of the ever-growing collection of raw EST traces. This will enable researchers to create cleaner EST sequences for downstream applications and to extract previously

overlooked information. Using ***WebTraceMiner***, the lab has built ***ConiferEST***, the first public database that presents both the complexity and abnormality of EST termini to the bioinformatics community.

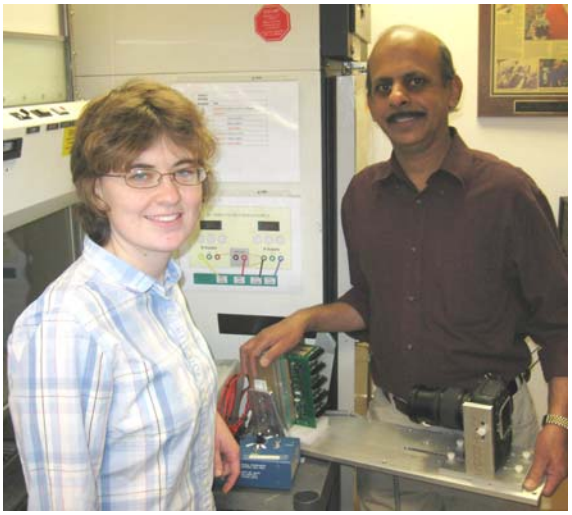
A second bioinformatics software package developed by Liang's lab is called WebGMAP. This offers a powerful platform for examining gene structures and variation, and for exploring many interesting biological processes such as alternative splicing, alternative polyadenylation and genetic polymorphisms. Using these in-house tools, we created ***ChlamyEST-Termini*** database, which represents a unique public resource that anchors individual *Chlamydomonos reinhartdii* ESTs and their termini to their genome. Chun Liang and students are actively expanding their databases to cover more plant species, including *Arabidopsis thaliana* and *Oryza sativa*. The huge data sets that they have compiled are facilitating *in silico* research work on fundamental biological questions that concern the transcriptome, mRNA metabolism, and gene expression and regulation.

## Collaborative Research between Miami University and NASA on a Space Project

Research in the Kiss lab is dynamic and involves collaborative efforts by research teams across the United States including a large group of researchers at NASA Ames Research Center in California. Members of this group include biologists, engineers, and project managers. Recently, the PI team at Miami University (Drs. John Z. Kiss and Richard E. Edelmann) and collaborators designed an experiment to investigate the impact of long-term storage in flight certified hardware on *Arabidopsis* seed germination. This ground study was designed to investigate why there was lower than anticipated seed germination during the last two flights of the TROPI experimental runs. *Arabidopsis* seed samples were flown to space on two missions in 2006, when experiments were conducted on the International Space Station. Data on the growth and tropistic responses of seedlings (video tapes) are currently being analyzed at Miami University, while gene expression studies are being conducted on frozen samples of the seedlings that grew in space by a collaborator, Dr. Melanie J. Correll at the University of Florida.

In December 2008, post-doctoral fellows Drs. Prem Kumar and Kathy Millar (photographed below), flew to NASA-Ames Research Center to set up the long-term storage test. While at the research center, both had the opportunity to meet and discuss the experiment with members of the NASA Ames research team. When asked what it is like to work at NASA-Ames, Dr. Kumar answered:

"We always receive strong support from the science and engineering teams in materializing our objective. The advantage of performing these biocompatibility experiments at NASA-Ames is that at every point of flight build or ground testing there is direct supervision by their Quality Assurance team. Thus we employ the state-of-the-art technology to meet our long-term goals of understanding plant development in space. "

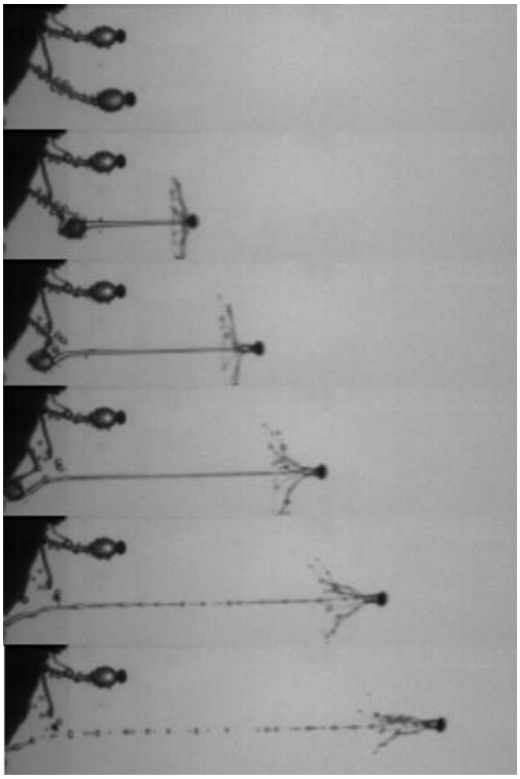


Besides the research conducted at NASA-Ames, additional ground control experiments using flight hardware are being executed here at Miami. Ground experiments are essential pre-flight studies because they help to remove experimental error when flight to International Space Station becomes possible. In fact, NASA is considering a follow-up space experiment to study plants at fractional gravity (Moon-Mars conditions) in early 2010. Several interesting publications are anticipated from the TROPI project, as much progress has been made to understand tropistic responses of *Arabidopsis* in microgravity conditions of space. The initial results of data analyses reveal novel tropistic responses of *Arabidopsis* seedlings in microgravity. This exploratory research will be important for the long-term cultivation of plants in space.

## The Fastest Flights in Nature: Spore Discharge Mechanisms in Fungi

Microscopic coprophilous or dung-loving fungi help make our planet habitable by degrading the billions of tons of feces produced by herbivores. But the fungi have a problem: survival depends upon the consumption of their spores by herbivores and few animals will graze on grass next to their own dung. Evolution has overcome this obstacle by producing an array of mechanisms of spore discharge whose elegance transforms a cow pie into a circus of microscopic catapults, trampolines, and squirt guns. Recent research from Dr. Nik Money's lab in the botany department, in collaboration with Dr. Diana Davis and Dr. Mark Fischer at the College of Mount St. Joseph in Cincinnati, solves the operation of squirt guns that fire spores over distances of more than 2 meters. The researchers used high speed cameras running at up to 250,000 frames per second to capture these blisteringly fast movements. Spores are launched at maximum speeds of 25 meters per second – impressive for a microscopic cell – corresponding to accelerations of 180,000 *g*. In terms of acceleration, these are the fastest flights in nature.

This is the first study utilizing ultra-high-speed video cameras to capture the events of spore discharge in ascomycete and zygomycete fungi. Previous investigators relied upon models to predict ballistic parameters and produced erroneous estimates of velocities and accelerations. These estimates were then used to suggest that pressures within the spore guns were very high. Fungal cells generate pressure by osmosis and in the new work the authors used a combination of spectroscopic methods to identify the chemical compounds responsible for driving water influx into the guns. These experiments showed that the discharge mechanisms in fungi are powered by the same levels of pressure that are characteristic of the cells that make up the feeding colonies of fungi. Therefore, the long flights enjoyed by spores result not from unusually high pressure, but from the way in which explosive pressure loss is linked to the propulsion of the spores. There appear to be some similarities between the escape of the spores and the expulsion of ink droplets through nozzles on inkjet printers.



**Sporangial discharge in *Pilobolus kleinii*. This illustration is a montage assembled from separate image files from video recordings obtained at a frame rate of 50,000 frames per second. The launch is completed in less than 0.25 milliseconds; an eye blink takes 100 milliseconds, or 400 times longer! Original research published in Yafetto, L. et al. 2008. The fastest flights in nature: high-speed spore discharge mechanisms among fungi. *PLoS ONE* 3(9): e3237. doi:10.1371/journal.pone.0003237**

Another important aspect of the new work is the way that it has allowed the researchers to test different models for the effect of viscous drag on microscopic particles. This information is very important for future biophysical studies on spore and pollen movement, which have implications for the fields of plant disease control, terrestrial ecology, indoor air quality, atmospheric sciences, veterinary medicine, and biomimetics. Finally, the paper was co-authored by 6 undergraduates, and 3 graduate students who worked for hundreds of hours to obtain the video footage. Some of the videos are so beautiful that student Hayley Kilroy (one of the authors) set them to music and posted them on YouTube. Research in Nik's Money's lab on spore discharge in fungi is currently funded by NSF and NIH.

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