

RECENT SUCCESSSES

Dr. Andrew Doust was awarded a 4-year grant totaling \$3.2 million from the NSF, and published two papers in *PNAS*.

Dr. Mark Fishbein was awarded a \$642,000 -3 year grant from the NSF.

Dr. Janette Steets is a Key Personnel Member on an HHMI Grant of \$1.5 million to develop authentic research experiences in freshman labs. She was named OSU Sigma XI Young Investigator of the year.

Dr. David Meinke was elected Fellow of AAAS.

Dr. Gerald Schoenknecht published a paper in *Science*.

The 2015 edition of *Flora of Oklahoma* was published.



Department of Botany, OSU

Bluestem Summer 2015

Dear Botany Alumni and Friends,

The OSU Botany Department is still going strong! Three faculty members received major grants in 2014-15 from the National Science Foundation (NSF) and the Howard Hughes Medical Institute (HHMI) totaling over \$5.3 million dollars! Others continued their multi-year funded projects. Three were on sabbatical in Germany, Mexico, and California. We hired a new faculty member who starts in 2015-16, Dr. Henry Adams, a plant ecologist specializing in climate change. And we have a new Unit Assistant, Mary Jane Kendall, who came to us from the Cypress-Fairbanks Independent School system in Houston. She is an Oklahoma native who attended OSU, and is excited to be back in Stillwater.

We had 14 graduate students in 2014-15. Many were supported by fellowships from OK-LSAMP, NSF, The Smithsonian, and the OSU Graduate College. In addition, our students received research and travel grants from federal agencies and professional societies. Angela McDonnell was selected for the 2015-16 Botany Graduate Scholarship. Her doctoral research is supported by an NSF-DDIG award and by numerous grants from professional societies. Recent graduates include Josh McCloud who is a PhD student at University of Tulsa, and Chad Ternes who is starting a new postdoc at Michigan State. Michael Cobbs and Tristan Wulfers are working in the environmental sciences field.

Our undergraduate program continues to be small, but we are delighted that all of our graduates are employed in the profession or are in graduate programs at OSU and elsewhere! Jodie Crose (top left photo with Dean Danilowicz) was selected as the Outstanding Botany Senior in 2015. She served as the Spears Herbarium Fellow and was selected as a participant in an NSF-REU program. The Botany student club OSUBS (bottom left photo) continues to be active, and the graduate students recently started a Botany chapter (BGSO) of the OSU Graduate and Professional Student Government Association.

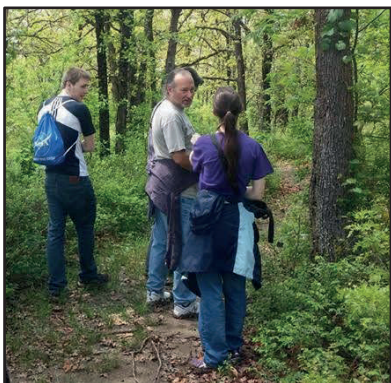
We hope you enjoy this edition of *Bluestem*, which highlights faculty and student activities. And please stay in touch! We'd love to hear what you are up to.

Best regards,

Linda Watson
Head and Professor of Botany, linda.watson10@okstate.edu
<http://botany.okstate.edu>

Our student organization **OSUBS** has had an eventful spring 2015 semester! They hit the ground running in February with their workshop and potluck titled “Escape to the Tropics.” Participants brought Caribbean-style dishes to share, and professors Drs. Linda Watson and Elizabeth Friar, along with graduate student Dylan Franks, shared photos of native flora from their trips to warmer climates. Their next workshop/potluck, “Starting your own garden from seed” was a huge success, bringing in new OSUBS members and botanical enthusiasts. Dr. Lane Greer gave wonderful tips on how to make the most of beautiful spring gardens. A lottery for conference travel was also held, with two undergraduate and two graduate students claiming awards!

OSUBS also co-sponsored many events throughout the semester, including the annual Library-Botany Seminar Series: Plants, People, and Beyond with speaker Dr. Kelly Kindscher (University of Kansas), and the Science Café presentation “Monarchs & Milkweeds: An Iconic Interaction under Threat,” Drs. Mark Fishbein and Kristen Baum, (Dept. Integrative Biology). In April, OSUBS hosted a field trip to the groundbreaking of the new Tulsa Botanic Garden; students were led through natural paths to identify native and invasive plant species of Oklahoma. The annual photo contest drew in close to 100 entries! The winning photos will be featured in the OSUBS calendar for 2015-2016.



Dr. Fishbein, Lindsey Worcester, Tucker Whitlow, along the trails of the Tulsa Botanic Garden.



Officers for 2014-2015. communications coordinator Nicole Parker, treasurer Lindsey Worcester, secretary Angela McDonnell, vice president Ky Shen, president Suzanne Coveley, and faculty advisor Dr. Mark Fishbein.

Photo Contest Winners 2015



1st place winner – Orchid, from Nicole Bryant Parker - 2nd place winners – *Oxalis*, from Dylan Franks and *Euphorbia* Mark Fishbein, and 3rd place winner – *Eryngium Heterophyllum*, Mark Fishbein.

David Meinke continues to work on *Arabidopsis* genetics in the basement of Life Sciences East, teach General Genetics (BIOL3023) to a diverse population of undergraduate students, and contribute to the *Arabidopsis* research community. Ph.D. student Nicole (Bryant) Parker and research associate Yixing Wang are doing the “heavy lifting” these days for an NSF-funded project. This work highlights an interesting example of a tandem gene duplication in *Arabidopsis*, helps to explain the range of embryo defects found in mutants disrupted in essential chloroplast functions, and underscores the value of using natural variation in *Arabidopsis* accessions collected worldwide to study the relationships between

chloroplast translation, fatty acid biosynthesis, protein import, and plant development. Nicole started working in the lab several years ago as an undergraduate student, mentored by Colleen Sweeney, and then readily transitioned into the graduate program. Nicole has admirably presented the lab's work at International Arabidopsis conferences in Paris, France, and Sydney, Australia. She has also become a trusted TA in General Genetics. Yixing joined the lab several years ago and has contributed valuable expertise in molecular biology. Frequently, her results serve to distinguish between alternative models based solely on genetic analyses. Recently, Yixing has split her time between the Meinke lab and that of her husband, Ming Yang, which is located right across the hallway. For Dr. Meinke, recent highlights include his election as Fellow of the American Association for the Advancement of Science (AAAS), and a Spring 2015 sabbatical spent exploring human genetics at the UCSF School of Medicine in San Francisco, and assisting curators in Redwood City, a short drive south, with manual curation of the Arabidopsis genome. On a sad note, the Meinke lab continues to mourn the 2013 loss, from cancer, of Rosanna Muralla, a former research associate whose smile and technical expertise often made even difficult lab days more pleasant and meaningful.

The Henley lab continues to study the ecophysiology of algae in the contexts of extreme environments and biofuels production. The focus is on algal cultivation techniques to support high growth rates and production of fats that serve as the direct feedstock for biodiesel. Tristan Wulfers received his M.S. "Productivity and resource use efficiency in a microalgal polyculture under different levels of CO₂ and phosphorus supply." He works as a Water Quality Lab Technician for the City of Tulsa. In 2015, Michael Cobbs successfully defended his M.S. thesis, "A novel aggregating growth habit in *Dunaliella* spp. (Chlorophyta, Dunaliellales)." He now works for Accurate Environmental Labs in Stillwater. Michael, Dylan Franks, current Plant Science Ph.D. student, and Dr. Henley each presented research results at the Joint Aquatic Sciences Meeting in Portland, OR in July 2014. Bill also presented research results at the Algae Biomass Summits in 2013 (Orlando, Florida) and 2014 (San Diego, California). Dr. Lucie Novoveská, postdoctoral fellow on Henley's 2011-13 OCAST project, "Continuous Cultures of Algae: Basic Research toward Biofuels," is employed as a senior research scientist at Algae Systems, LLC in Daphne, Alabama.

Mark Fishbein has been awarded a 3-year NSF grant totaling \$642,000 to study the evolution of milkweed species using genome sequences. Milkweeds are important components of the diversity of North American prairies and are the host plants of the monarch butterfly, a species of considerable conservation interest. In previous research, Fishbein investigated the evolution of milkweed defenses in response to monarch feeding. However, the evolutionary relationships among milkweed species are still not well understood.

Reconstructing the past evolution of plant species is especially problematic because rapid diversification of new species often leaves conflicting signals in the DNA sequences that make up plant genomes. Milkweeds are no exception. Fishbein's newly funded project will use an unprecedentedly large number of genes and novel analytical approaches to untangle the conflicting evolutionary signals present across the genome.

This study will answer questions about where milkweeds originated and how they became distributed from Canada to South America. It will provide a basis for better understanding the coevolution between milkweeds and monarch butterflies and the evolution of plant defense, as well as provide a context for interpreting the results of other studies of the pollination, reproduction, and genome evolution of milkweeds. More generally, this research will demonstrate the feasibility of solving difficult phylogenetic problems at the species level in plants by employing improvements in next-generation sequencing techniques. The work combines methods for targeted sequencing of hundreds of specific regions of the nuclear genome applied to unusually large samples of each species.

The project will train graduate and undergraduate students at OSU in cutting edge bioinformatics and genomic methods and develop new educational materials about monarch and milkweed co-evolution at the OSU Botanical Garden.



The Digital World of Herbarium Specimens. With grant support from the Andrew W. Mellon Foundation, Botany graduate students Angela McDonnell and Lindsey Worcester digitized all of the type specimens in the OSU Herbarium. Type specimens are collections to which scientific names are directly attached and are annotated over time to reflect changes in taxonomy. A botanist working on a specific group of plants will often rely on the type specimens to decipher the taxonomic history of the group. For example, to study the taxonomy of *Asclepias oenotheroides* (the longhorn milkweed), which over time has been described as six different species, one needs to examine the type specimens of each of those named species. Such studies have shown these type collections represent a single variable species and the correct name is *A. oenotheroides*.

Because type specimens are important collections, many of which are very old, some herbaria will not send type specimens along with loaned specimens. Due to funding constraints, only some of the largest herbaria have their specimens digitized and available as high-resolution images online (JSTOR Global Plants, <http://plants.jstor.org>). This means, until recently, if you wanted to see the type specimens from the OSU Herbarium, you needed to arrange a visit in person to do so or request a loan.

Angela and Lindsey transported all 288 type specimens held in the OSU Herbarium to the Botanical Research Institute of Texas in Fort Worth and used their state-of-the-art equipment for imaging. On return, they entered all of the information printed on the specimen labels into a database, and transfer of the images and associated data to JSTOR is in progress. Soon anyone with an internet connection will be able to access information about OSU's valuable collection of botanical type specimens!

Fun times in Mexico – **Dr. Andrew Doust!** In the fall of 2014 my family and I went on sabbatical to Mexico City. My wife is an associate professor of art history at OSU and wanted to study Franciscan archives and their use of images, and I was keen to work with one of the pioneers of gene network models, Dr. Elena Alvarez-Buylla, at the Instituto de Ecología, Universidad Nacional Autónoma de México, in Mexico City. Thus, with our interests converging, we set out with our two young children, Emilio and Isabela, for five months in Mexico. We rented a house in Coyoacán in the south of the city, near the university, and found a little private school for our children. This school was conducted almost entirely in Spanish, so was a challenge for our monolingual kids! While we were in Mexico City we went on several field trips, emphasizing either art history, botany, or both, culminating in a visit to one of the monarch butterfly refuges high in the mountains of Michoacán. This is where most of the butterflies from North America migrate each year to pass the winter, before they and their offspring return northward the next spring. Our children were well adjusted to walking at a high altitude by that time, and bounded up the path to the butterflies at over 11,000 feet. It was early in the season but we were fortunate as it was still warm enough for swarms of butterflies to be taking off from and alighting on the great masses of butterflies hanging from the pines. These high altitude forests are incredibly species rich, with, for example, over 20 species of edible mushrooms fruiting while we were there. We know that because we saw them being brought down as we climbed, and later tasted the delicious *sopa de hongo* when we came down!

My sabbatical was mostly concerned with learning how to analyze gene networks while Cristina wrote a book, but the experience of living in Mexico for five months was much more than that. For instance, in Mexico, fiestas matter! When Emilio turned six the whole school sang and danced for him, and we had a five foot Spiderman piñata that was packed full of candy to break! Traditional celebrations, like Day of the Dead and posadas at Christmas time added to the richness of daily life. We will miss that!

Over the past few years, **Dr. Gerald Schoenknecht's** research has extended into the exciting field of evolutionary genomics of extremophiles. These organisms live in extreme habitats such as hot, acidic volcanic pools. Collaborating with colleagues from universities in the US and Germany, he studies the microscopic red alga, *Galdieria sulphuraria*. This species lives next to volcanic fumaroles, and has been found in heavy metal-laden drainage of old mineshafts, an environment similar to hot battery acid.

To understand how this unicellular red alga has adapted to extreme environments, an international team sequenced and analyzed the organism's genome. Surprisingly, at least 5% of the genes in *G. sulphuraria* were directly acquired from bacteria living in the same environment. Horizontal gene transfer, the exchange of genes between species, is common in bacteria and is responsible for the rapid spread of antibiotic resistance. In contrast, horizontal gene transfer in eukaryotes (algae, plants, fungi, animals) was believed to play little to no role in evolution. The unexpected discovery that *G. sulphuraria* adapted to its hostile environment, at least in part, by stealing or copying genes from extremophile bacteria, was published in *Science* and received widespread attention from the media including *National Geographic*.

In 2014-15, Gerald was on sabbatical in Düsseldorf, Germany, where he performed further analyses of how *G. sulphuraria* and its closely related species adapted to their hostile environments. He investigated gene expression to understand how the type and number of proteins have changed as these species adapted to different environmental conditions. Moreover, genomes were sequenced from closely related *Galdieria* species adapted to slightly different environments, e.g., lower growth temperatures. Together these investigations will provide a more detailed picture of the molecular mechanisms that allow extremophiles to thrive in their inhospitable environments.

Dr. Ron Tyril has remained active in retirement and has been busy with his world travels and teaching his wildflower course in Great Britain. He and collaborators, including **Dr. Linda Watson**, published a 2015 edition of the *Flora of Oklahoma: Keys and Descriptions*. This edition includes an updated taxonomy that reflects changes brought about by molecular systematics. It has keys to all 178 vascular plant families, 926 genera, and 2659 species that occur in Oklahoma, with written descriptions for all families. The 'Flora group' is presently working on a comprehensive book on the Sunflower Family (Asteraceae) in Oklahoma that will include descriptions for all genera and species, plus illustrations.

Recent graduates, where they are now.....

Rob Bieloh (BS), greenhouse manager, *A New Leaf* (Tulsa), non-profit
Nadja Goertz (BS), medical student, OSU Osteopathic School of Medicine
Alesia Hallmark (BS), PhD student, University of New Mexico
Lydia Meador (BS), PhD student, Arizona State University
Wyatt Sharber (BS), PhD student, University of Miami
Mary Gard (BS, MS), PhD student, Oklahoma State University
Molly Parkhurst (BS, MS), water quality analyst, City of Tulsa
Lupita Borja Ivener (MS), lab technician, Midwest Laboratories (Omaha)
Kate Halpin (MS), horticulturalist, California Carnivores (Sonoma)
Johnny Lloyd (MS), PhD student, Michigan State University
Kelly Magrath (MS), high school counselor, Putnam City
Michael Malahy (MS), high school science teacher, Putnam City
Jake Long (MS), R&D director, *Entogenetics* (Charleston)
Matt Allen (PhD), faculty member, Seminole State College
Dan McGlinn (PhD), faculty member, College of Charleston
Som Punnuri (PhD), postdoctoral researcher, Fort Valley State University
Vaskar Thapa (PhD), postdoctoral researcher, University of Pennsylvania

Let us know where you are today!

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Stillwater OK 74078-3013**

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- Botany Scholarship Fund** (2290090) [supports undergraduate student scholarships and awards]
- James K. McPherson Fund** (225090) [supports graduate student field research and conference travel]
- Betty & Richard Speairs Fellowship** (223250) [supports an undergraduate herbarium assistant]

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