Botanical Society Of America

Plant Science Bulletin

Fall 2013 Volume 59 Number 3

Botany in Action - in New Orleans!

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From the Editor

The good news these days is about resources. There is so much information readily available on the internet that one hardly needs to leave the office to work on a literature review or gather information for a lecture. The first step—Google it! The bad news these days is about resources. There is so much information readily available on the internet that one could spend hours sorting through possible sites to find the information you want. What we need is a resource that has done the dirty work of searching what is available and evaluating its usefulness. That resource has been provided for botanical and lichenological systematic research by Morgan Gostel, Manuela Dal-Forno, and Andrea Weeks in this issue. This is also a great resource to use for teaching images.

In our other feature article, Melanie Link-Pérez and Elizabeth Schussler demonstrate that resources, by themselves, are not enough to support grade-school teachers in their efforts to introduce plant science to students. At this age the kids love plants and so do the teachers, and the teachers are anxious to find and use resources to help them incorporate plants into the curriculum. What they need even more, however, is greater exposure to plant-based activities in their preservice training. Are you looking for broader impact? Here is a defined target to aim for. Collaborations with individual schools or individuals teachers are great, but collaborations with teacher trainers in education departments will have much greater overall impact.

By the way, if you were not in New Orleans, you missed a GREAT conference. It took the Society 37 years to go back to New Orleans for an annual meeting, but I don't think we'll wait that long to visit again. But that's behind us now, and mostly below sea level. Next year we'll be back on higher ground—look forward to Boise.

-Marsh

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Congratulations to all Botany 2013 Award Winners













For a complete listing of Awards and Winners see: http://www.botany.org/awards_grants/2013Awardrecipients.php

Award Winners

In the last edition of the Plant Science Bulletin (http://www.botany.org/plantsciencebulletin/PSB-2013-59-2.pdf), we listed a number of Botanical Society of America award winners. We're pleased to continue the list of winners in the following pages.

Jeanette Siron Pelton Award

The Jeanette Siron Pelton Award is given for sustained and imaginative productivity in the field of experimental plant morphology.

Professor Mitsuyasu Hasebe, National Institute for Basic Biology (Japan)

The 2013 Grady L. Webster Award

This award was established in 2006 by Dr. Barbara D. Webster, Grady's wife, and Dr. Susan V. Webster, his daughter, to honor the life and work of Dr. Grady L. Webster. The American Society of Plant Taxonomists and the Botanical Society of America are pleased to join together in honoring Grady Webster.

Drs. Jessica M. Budke, Bernard Goffinet, and Cynthia S. Jones. The cuticle on the gametophyte calyptra matures before the sporophyte cuticle in the moss *Funaria hygrometrica* (Funariaceae) *American Journal of Botany*, 2012, 99(1): 14-22

http://www.amjbot.org/content/99/1/14.full.pdf+html

Given by the Sections

Margaret Menzel Award (Genetics Section)

The Margaret Menzel Award is presented by the Genetics Section for the outstanding paper presented in the contributed papers sessions of the annual meetings.

This year's award goes to **Dr. Ingrid Jordon-Thaden**, University of Florida, for the paper "Differential gene expression and loss in two natural and synthetic allotetraploid Tragopogon species (Asteraceae) and their diploid progenitors"

Co-authors: Lyderson Viccini, Richard Buggs, Michael Chester, Ana Veruska Cruz Da Silva, Srikar Chamala, Ruth Davenport, Wei Wu, Patrick S. Schnable, W. Brad Barbazuk, Douglas Soltis and Pamela Soltis

http://www.botanyconference.org/engine/search/index.php?func=detail&aid=936

George R. Cooley Award (Systematics Section and the American Society of Plant Taxonomists)

The ASPT's Cooley Award is given for the best paper in systematics given at the annual meeting by a botanist in the early stages of his/her career. Awards are made to members of ASPT who are graduate students or within 5 years of their post-doctoral careers. The Cooley Award is given for work judged to be substantially complete, synthetic, and original. First authorship required; graduate students or those within 5 years of finishing their Ph.D. are eligible; must be a member of ASPT at time of abstract submission; only one paper judged per candidate.

This year's award was given to **Ricardo Kriebel** of the New York Botanical Garden for the talk "Phylogenetic study of *Conostegia* demonstrates the utility of anatomical and continuous characters in the systematics of the Melastomataceae." Co-author: Fabian Michelangeli

http://www.botanyconference.org/engine/search/index.php?func=detail&aid=584

A.J. Sharp Award

(Bryological and Lichenological Section)

The A.J. Sharp Award is presented each year by the American Bryological and Lichenological Society and the Bryological and Lichenological Section for the best student presentation. The award, named in honor of the late Jack Sharp, encourages student research on bryophytes and lichens.

This year's A.J. Sharp Award goes to **Matthew Nelsen**, University of Chicago, for his paper "Lichen-associated algae: we hardly know you." Co-author: Steven D. Leavitt

http://www.botanyconference.org/engine/search/index.php?func=detail&aid=832

Edgar T. Wherry Award

(Pteridological Section and the American Fern Society)

The Edgar T. Wherry Award is given for the best paper presented during the contributed papers session of the Pteridological Section. This award is in honor of Dr. Wherry's many contributions to the floristics and patterns of evolution in ferns.

This year's award goes to **Sally Stevens,** Purdue University, for her paper; "No Place Like Home? Testing for Local Adaptation and Dispersal Limitation in the Fern *Vittaria appalachiana* (Vittariaceae)" Co-author: Nancy Emery

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=732

AWARDS FOR EARLY CAREER SCIENTISTS

Lawrence Memorial Award

The Lawrence Memorial Fund was established at the Hunt Institute for Botanical Documentation, Carnegie Mellon University, to commemorate the life and achievements of its founding director, Dr. George H. M. Lawrence. Proceeds from the Fund are used to make an annual Award in the amount of $2000 to a doctoral candidate to support travel for dissertation research in systematic botany or horticulture, or the history of the plant sciences.

The recipient of the Award is selected from candidates nominated by their major professors. Nominees may be from any country and the Award is made strictly on the basis of merit—the recipient's general scholarly promise and significance of the research proposed. The Award Committee includes representatives from the Hunt Institute, The Hunt Foundation, the Lawrence family, and the botanical community.

The Lawrence Memorial Award for 2013 goes to **Aleksandar Radosavljevic**, student of Dr. Patrick Herendeen of the Chicago Botanical Garden and Northwestern University. The proceeds of the award will help support his travel for field and collections-based work in integrative research study of the genus *Cynometra*.

BSA Public Policy Award

The Public Policy Award was established in 2012.

Kathryn Ann Lecroy, University of Pittsburgh, Advisor: Lindsey Tuominen

Michael Cichan Award

(Paleobotanical Section)

This award was named in honor of the memory and work of Michael A. Cichan, who died in a plane crash in August of 1987, and was established to encourage work by young researchers at the interface of structural and evolutionary botany. This award is given to a young scholar for a paper published during the previous year in the fields of evolutionary and/or structural botany.

The Michael Cichan Award for 2013 is presented to **Anne-Laure Decombeix**, French National Center for Scientific Research at UMR AMAP Montpellier.

Isabel Cookson Award
(Paleobotanical Section)

Established in 1976, the Isabel Cookson Award recognizes the best student paper presented in the Paleobotanical Section.

Dori Contreras from the University of California-Berkeley, is the 2013 award recipient for the paper, "New data on the structure and phylogenetic position of an extinct Cretaceous redwood." Co-authors: Garland Upchurch and Greg Mack.

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=749

Katherine Esau Award
(Developmental and Structural Section)

This award was established in 1985 with a gift from Dr. Esau and is augmented by ongoing contributions from Section members. It is given to the graduate student who presents the outstanding paper in developmental and structural botany at the annual meeting.

This year's award goes to **Luke Nikolov**, from Harvard University, for the paper "Developmental origins of the world's largest flowers." Co-authors: Peter Endress, M Sugumaran, Sawitree Sasirat, Suyanee Vessabutr, Elena Kramer and Charles Davis.

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=874

Maynard Moseley Award
(Paleobotanical and Developmental and Structural Sections)

The Maynard F. Moseley Award was established in 1995 to honor a career of dedicated teaching, scholarship, and service to the furtherance of the botanical sciences. Dr. Moseley, known to his students as "Dr. Mo," died Jan. 16, 2003 in Santa Barbara, CA, where he had been a professor since 1949. He was widely recognized for his enthusiasm for and dedication to teaching and his students, as well as for his research using floral and wood anatomy to understand the systematics and evolution of angiosperm taxa, especially waterlilies (*Plant Science Bulletin*, Spring, 2003). The award is given to the best student paper, presented in either the Paleobotanical or Developmental and Structural sessions, that advances our understanding of plant structure in an evolutionary context.

Robert A. Stevenson, from University of California - Berkeley, is the 2013 Moseley Award recipient for his paper "Flight of the conifers: Reconstruction of the flight characteristics of Paleozoic winged conifer seeds." Co-authors: Dennis Evangelista and Cindy V. Looy.

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=328

Samuel L. Postlethwait Award
(Teaching Section)

The Samuel L. Postlethwait Award is given by the Teaching Section of the BSA for outstanding service to botanical education.

This year's award goes to **Dr. James Wandersee**, Louisiana State University.

Developmental & Structural Section Student Travel Awards

Abigail Mazie, University of Wisconsin-Madison - Advisor, Dr. David Baum—Botany 2013 presentation: "Understanding cell shape diversity: the evolution of stellate trichomes in *Physaria* (Brassicaceae)" Co-author: David Baum

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=331

Adrian Dauphinee, Dalhousie University - Advisor, Dr. Arunika Gunawardena—Botany 2013 presentation: "Comparison of the early developmental morphologies of *Aponogeton* madagascariensis and *Aponogeton* boivinianus." Co-authors: Christian Lacroix and Arunika Gunawardena

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=911

Lachezar Nikolov, Harvard University - Advisor, Dr. Charles Davis—Botany 2013 presentation: "Developmental origins of the world's largest flowers." Co-authors: Peter Endress, M Sugumaran, Sawitree Sasirat, Suyanee Vessabutr, Elena Kramer and Charles Davis

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=874

Li-Fen Hung, National Taiwan University - Advisor, Dr. Ling-Long Kuo-Huang—Botany 2013 presentation: "The growth strain and anatomical characteristics of tension wood in artificially inclined seedlings of *Koelreuteria henryi* Dummer." Co-author: Ling-Long Kuo-Huang

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=135

Bhawana Bhawana, Middle Tennessee State University - Advisor, Dr. Aubrey B. Cahoon - Botany 2013 presentation: "Visualization of 3-Dimensional Plant Cell Architecture with FIB-SEM." Co-authors: Joyce Miller and Aubrey Cahoon

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=265

Developmental & Structural Section Best Student Poster Award

Katie Downing, Eastern Michigan University, for the poster "A S.E.M. survey of Carnivorous North American Purple Pitcher Plant Leaves, Sarracenia purpurea (Sarraceniaceae)." Co-author: Margaret Hanes

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=600

Ecology Section Undergraduate Student Presentation Award

Jenna Annis, Eastern Illinois University, for the paper "Seed Ecology of Federally Threatened *Pinguicula ionantha* (Godfrey's Butterwort)." Co-authors: Jennifer O›Brien, Janice Coons, Brenda Molano-Flores and Samantha Primer

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=335

Nia Johnson, Howard University, for the poster "Herbivory Response of *Murgantia histrionica* to a Ni-hyperaccumulator, *Alyssum murale*." Co-authors: Chandler Puritty and Mary McKenna

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=507

Chandler Puritty, Howard University, for the poster "Herbivory Response of *Murgantia histrionica* to a Ni-hyperaccumulator, *Alyssum murale*." Co-authors: Nia Johnson and Mary McKenna

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=507

Ecology Section Graduate Student Presentation Award

Ian Jones, Florida International University, for the paper "Temporal and developmental changes in extrafloral nectar production in *Senna mexicana* var. *chapmanii*: is extrafloral nectar an inducible defense?"

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=162

Ecology Section Student Poster Award

Jordan Ahee, Trent University, for the poster "Evidence of restricted pollen dispersal in *Typha latifolia*." Co-authors: Marcel Dorken and Wendy Van Drunen

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=930

Economic Botany Section Student Travel Awards

Taylor Nelson, Weber State University - Advisor, Dr. Sue Harley, for the paper "Survey for helenalin among Utah Asteraceae species."

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=357

Sushil Paudyal, Old Dominion University - Advisor, Dr. Govind P. S. Ghimire, for the paper "Plants used in religious ceremonies by Tharu culture in Dang Valley (Nepal)."

http://www.botanyconference.org/engine/search/index.php?func=detail&aid=861

Genetics Section Student Poster Award

Meng Wu, Miami University, for the poster "The investigation on protein evolution of Y chromosome in *Carica papaya.*" Co-author: Richard Moore

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=581

Physiological Section Li-Cor Prize

Samuel Del Rio, California State University - Bakersfield, for the paper "Hydraulic conductance is coordinated at the leaf and stem levels among chaparral shrubs." Co-authors: Christine Hluza, Evan D. MacKinnon, Jeffrey Parker and R. Pratt

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=812

Physiological Section Best Student Paper Award

Kerri Mocko, University of Connecticut - Advisor, Dr. Cynthia Jones, for the poster "Physiological responses to drought reflect phylogenetic history in South African *Pelargoniums* (Geraniaceae)." Co-author: Cynthia Jones

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=302

Physiological Section Best Student Poster

Robert "Berto" Griffin-Nolan, Ithaca College - Advisor, Dr. Peter Melcher, for the poster "The physiological responses of moss to greenlight." Co-author: Peter Melcher

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=73

Marta Percolla, University of Connecticut - Advisor, Dr. Cynthia Jones, for the poster "Reduced number of vessel connections is positively associated with greater cavitation resistance to water stress in chaparral shrubs" Co-authors: R. Pratt, Anna Jacobsen and Michael Tobin

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=823

Tropical Biology Section Best Student Paper Award

Beyte Barrios Roque, Florida International University, for the paper "Herbivory in fragmented populations of the Pineland golden trumpet (*Angadenia berteroi*)." Co-authors: Andrea Salas and Suzanne Koptur

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=117

Laura Lagomarsino, Harvard University, for the paper "Of Bats, Birds, and Berries: Phylogeny and Evolution of the Species-Rich Neotropical Lobelioids (Campanulaceae)." Co-author: Charles Davis

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=752

Melissa Johnson, Claremont Graduate University, for the paper "Evolution of reproductive barriers within a non-adaptive hyper-species-rich radiation of Hawaiian Cyrtandra (Gesneriaceae)." Co-author: Elizabeth Stacy

http://2013.botanyconference.org/engine/search/index.php?func=detail&aid=702

Second Annual BSA Public Policy Committee Capitol Hill Visit

This year (2013) marks the first year that the BSA Public Policy Committee has offered a Public Policy Award. This award supports student and early career BSA-member applicants to travel to Washington, D.C. and participate in the annual Biological and Ecological Sciences Coalition (BESC) Congressional Visits Day. This two-day event is co-organized by the BESC and American Institute for Biological Sciences (AIBS) and is attended by scientists from around the United States. During the first day, participants receive training in effective communication with policy makers, followed by an opportunity for the constituent scientist participants to meet with their elected representatives and senators to discuss the impact and importance of federal funding for basic research in the biological sciences.

Last year, former BSA student representative to the Board, Dr. Marian Chau, and current student representative, Morgan Gostel, participated in the event. The success of the event resulted in the establishment of the annual BSA Public Policy Award by the BSA Public Policy Committee and the BSA Awards Committee. This year, two BSA members, Dr. Lindsey Tuominen and Kate LeCroy (PhD student), received the first of these awards. The awardees were joined by BSA student representative, Morgan Gostel (a PhD Candidate located at George Mason University, in close proximity to D.C.). The three attendees share their experience in this article.

As we are all well aware, Congressional partisanship has reached historic levels and is resulting in significant budget uncertainty, which has permeated all levels of government and affected the amount of funds available for biological research. Biological research touches all of our lives, whether spurring innovation, improving food security, or protecting biodiversity and understanding the needs of a healthy ecosystem. There is a substantial return on the investment in basic research, including the maintenance of a well-trained workforce prepared to face mounting global challenges ahead. The Congressional Visits Day provides a unique opportunity for researchers to meet with members of Congress and share their experience as citizens, educators, and researchers.

Lindsey's Experience:

Although I have previously participated in science policy in small ways, I had never before been to Capitol Hill or spoken in person with any federal policymaker. Curious about the world of science policy, I was keen to attend the science policy career panel sponsored by the Ecological Society of America, receive training from AIBS, and discuss support for NSF with policymakers.

The career panel included Alan Thornhill, the Director of the Office of Science Quality and Integrity with the USGS; Laura Petes, Ecosystem Science Advisor with the Climate Program Office at NOAA; Ari Novy, Public Program Manager of the US Botanical Gardens; and Penny Firth, the Deputy Division Director for the Division of Environmental Biology at NSF. As one might guess from the range of job titles, learning about these individuals' career paths and day-to-day working life helped attendees better understand the diverse options available for PhD-level scientists to serve in the federal government. **Dr. Thornhill pointed out that science is highly respected and influential within the federal government when it has a seat at the table, but policymakers may not always remember to include science. Thus, scientists can potentially have a transformative effect on public policy.** Students considering science policy work should note that, while the ability to think scientifically is highly valued in such careers, a deep expertise in one area is less important than broad, interdisciplinary knowledge and a collaborative work orientation.

The training session was serendipitously timed, as the President's 2014 Budget Proposal had been released earlier that day. BESC co-chairs Nadine Lymn and Robert Gropp and AIBS Senior Public Policy Associate Julie Palakovich Carr gave an overview of the federal budget process, the impacts of the sequester and proposed budget on federal research funding, and tips on effectively communicating with federal policymakers. **It became clear in their mock Capitol Hill meetings that the way scientists usually discuss their research needs to be distilled even from an "elevator pitch" to a simple fifteen-second summary highlighting the work's broader impacts!**

On April 11, led by neuroscientist and AIBS Policy Intern Dr. Zach Rosner, Margaret Kosmala (PhD Candidate, University of Minnesota/National Museum of Natural History), Andrew Adrian (PhD Candidate, University of Iowa), and I met with Senate staff members representing Minnesota (Klobuchar and Franken), Iowa (Grassley), and Illinois (Durbin) and Representative staff members representing Minnesota (Ellison and McCollum), Illinois (Davis), and Andrew's home state of Alabama (Aderholt). In discussing NSF's basic research funding, we came to realize that most elected officials were highly receptive to our message and supportive of basic biological research—cause for optimism that the relatively restricted impacts on NSF funding President Obama has proposed for 2014 will be supported within the legislative branch.

Throughout the trip, we were immersed in the world of scientists who had chosen what is often considered "one" alternative career path from the perspective of academic scientists. While the AAAS Science & Technology Policy Fellowships seem to be the most common way that scientists enter this world, the diverse options within the science policy career path were evident. Meeting Jasmine Hunt, Legislative Assistant to Senator Durbin, and Anna Henderson, an Energy Fellow with Senator Franken, further reinforced this idea—Dr. Hunt has training in chemistry and Dr. Henderson in geology. I am really honored that BSA gave me the opportunity to get this view of the science policy world, and I strongly encourage graduate students considering a career outside academia to apply for the BSA Policy Award in 2014!

Kate's Experience:

The Public Policy Award of the BSA afforded me the incredibly rewarding experience of civic engagement during a critical time for decision-making of our congressmen and congresswomen. I attended the science policy career panel discussion with Lindsey, and I also enjoyed the dialogue that I've often pondered but have not found easily accessible until now. Following this panel, we attended a boot camp on current science public policy topics—in fact, the most recent topic, the President's new fiscal year budget, was released the day of our workshop—and the gifted policy analysts at AIBS quickly read through it and had prepared a presentation, along with a summary of the projected impacts of sequestration on federal science agencies. As a student at the University of Pittsburgh and a Pennsylvania voter, I joined the team of students visiting congress members of Pennsylvania, Maryland, and the District of Columbia, specifically Senator Mikulski (D-MD), Senator Cardin (D-MD), Representative Hoyer (D-MD), Representative Norton (D-D.C.), Representative Cummings (D-MD), Senator Casey (D-PA), Senator Toomey (R-PA), Representative Thompson (R-PA), Representative Brady (R-PA), and Representative Doyle (R-PA). **Our message was simple yet strong: sustain investments in basic biological research.**

In regard to my state of Pennsylvania, Senator Casey and his science policy staffer were open and honest about the hard times of sequestration but stated that investing in federal science funding at a predictable level was a high priority. Representative Thompson was polite and receptive to our message while he leaned more toward supporting applied research and research that could be commercialized for economic benefit. Senator Toomey's science staffer was thankful for the stories I shared about how federal science funding has benefited my University's department of biological sciences, and he agreed with us that funding basic research can lead to solving problems and making advances for society. Lastly, the staffer of my own Pittsburgh Representative Doyle was happy to tell us that he signed a statement circulating around the House floor in support of the significant increases in federal science funding described by the president's budget. Every congress member or their staffer specifically voiced their pleasure to hear that not only does federal science funding support the scientist, but that there is an increasing commitment to bring our science out to our communities.

Beyond active research, we cannot secure the future of science without cultivating strong relationships with non-scientists and future scientists. This relationship should be especially strong with decision-makers, because as members of their constituency, we must maintain a stable voice to make the most positive and informative impact that we can. I encourage those interested in cultivating these relationships to increase your civic engagement and consider participating in Congressional Visits Day 2014!

Morgan's Experience:

This marked my second year participating in the Congressional Visits Day. Despite living and pursuing my PhD only 45 minutes outside of Capitol Hill, this is one of very few opportunities I have to meet with and speak directly to policymakers on the Hill. With regard to funding uncertainty, the contrast between this year and the last is remarkable. President Obama's budget proposal for fiscal year 2014 was released only two hours before the CVD briefing session (day one of the two-day event), so it was not until the morning of our congressional visits that specific details could be clarified regarding how the budget request might affect federal science agencies. These details were important, as the FY 2014 spending plan includes several proposals that support increases to science funding; among these is a $741 million increase to the current NSF budget.

I co-led my team (with Richelle Weihe, Federal Grants and Contracts Coordinator at the Missouri Botanical Garden) this year, which included scientist constituents from Missouri, North Carolina, and Virginia. Richelle represented Missouri and met with staffers from the offices of Representative Clay (D-MO) and Senator McCaskill (D-MO), while I met with staffers from the offices of Virginia Representative Connolly (D-VA) and Senator Warner (D-VA). Also in our team were two other graduate students: Gar Secrist, who was preparing to defend his Masters Thesis from the Virginia Institute of Marine Sciences, and Erin McKenney, a North Carolina resident and PhD student studying at Duke. Gar met with a legislative aid from Representative Wittman's office (R-VA), while Erin had meetings with a legislative aid for Senator Hagan (D-NC) and met directly with Representative Price (D-NC). Although our meetings with elected representatives included members with a range of political ideology, the message we had was generally well received. We were cautioned that the gulf of partisan divide remains wide and that it is likely that much congressional debate will continue before components of the President's proposed spending plan can be adopted.

As constituents and members of the BSA, you too can push for support of science funding simply by writing your elected members of Congress and asking them to support the President's FY 2014 proposed spending plan for the sciences. Tell your elected officials how federal funding for science impacts your research, your community, and the next generation of researchers who will drive global leadership in innovation. Request not only sustained support for the sciences, but a commitment to support this valuable investment. **Science funding is not and should not be made a partisan issue!** Your continued support of science policy can be as easy as joining the AIBS Action Center, which provides notification of important science policy news (http://capwiz.com/aibs/home/), and you can also play a role by joining the growing BSA Public Policy Committee (Contact Marian Chau for more information: marianmchau@gmail.com).

We thank the membership of the BSA for supporting this outreach opportunity to enhance basic scientific research policy by allowing young, active members of the botanical research community to participate in this capacity.

By Morgan Gostel, Lindsey Tuominen, and Kate LeCroy

BSA Seeks Editor for *Plant Science Bulletin*

The Botanical Society of America (BSA) is soliciting nominations for the position of **Editor** of the *Plant Science Bulletin* (*PSB*) to serve a five-year term, beginning January 2015. Both self- nominations and nominations of others are welcomed.

This is a rare leadership opportunity to contribute to the Society and the continued evolution of the *PSB*. We seek someone with desire to **pursue innovation and explore new ways to serve the Society**.

Duties of the Editor include both aspirational responsibility (helping shape a strategic vision for PSB, along with the PSB Editorial Committee and BSA Publications Committee) and operational responsibilities (soliciting contributions, coordinating reviews, working with Society office staff to produce copy, and recruiting new Editorial Committee members). Qualities of candidates should include a broad familiarity with different botanical specializations and especially botanical education, excellent communication skills, and a strong commitment to the Bulletin.

Review of nominations will begin on November 15, 2013. For the first stage of the review process, please submit a brief letter of nomination and a detailed vita of the nominated individual to Dr. Sean Graham, Search Committee Chair at swgraham@mail.ubc.ca.

The Committee may request additional information from candidates as the search process progresses. If you have questions or comments, please contact Dr. Graham.

Botany in Action Project Helps Bayou Rebirth Restore Wetlands Plants

Give a botanist a day off and a chance to make a difference, and what happens?

Well, if the example is that of 75 botanists at the Annual Conference of the Botanical Society of America, they put their hands and backs into restoration of the Louisiana wetlands.

Seanna Walsh of the University of Hawaii mixes soil during the Botany in Action project.

Every year during the conference, BSA organizes a Botany in Action field trip, giving the members a chance to give back to the host community. In 2013, that field trip was organized around Bayou Rebirth, a New Orleans non-profit devoted to hands-on wetlands restoration and stewardship.

"We offer volunteers and students an opportunity to engage in environmental restoration in a real way and learn about the issues facing an incredibly diverse, ecologically valuable, and significantly degraded ecosystem in their backyard," says Colleen Morgan, founder and director of the program, which is affiliated with Tulane University.

But not every volunteer group is quite like the botanists that poured off the bus in late July, ready with plant savvy and ready to learn about the Louisiana plants they were going to tackle. The group started in the backyard of an urban neighborhood, where Bayou Rebirth had a variety of gardens with native plants. They planted new seeds, moved garden beds, weeded, dug, and

At an urban office complex where the native species were used to landscape, the Botany in Action Team went to work weeding and planting.

toted blocks. All the work was accomplished while they fired off questions about the plants they were working with and the native habitat and environmental impact of the hurricanes and flooding of the low-lying neighborhood.

Camaraderie and laughter punctuated the sometimes serious discussions of environment and restoration of New Orleans wetlands. A few blamed the heat for the inevitable water fight, caused when a liner tarp had to be rinsed and the hose went rogue.

Part of the assignment was separating and replanting some of the wetlands species, something the botanists took on with smiles.

Next stop was an office complex, where the developer had decided a native landscaping would afford a more environmentally friendly option. BSA's volunteers formed teams and spread out to

Toting blocks from an old seedbed to create a new one called for some muscle.

accomplish the tasks laid out by Bayou Rebirth, sharing the tools and supplies to get the needed end results. As the heat of the New Orleans day grew, the enthusiasm of the botanical volunteers never waned for the task at hand. They moved gardens, spread mulch, planted seedlings, all while learning about the site's solar re-circulated filters and rain water systems.

Not only did they see it as a way to grow knowledge about species of plants they had not seen before, they saw it as a way to grow friendships among kindred spirits who care not only about botanical science but also about the world community.

Holding up muddy hands and wearing a big smile, one participant said, "I like to help out, and I'm learning about plants and digging in the dirt. It's fun!"

Another added, "It is fun, but it's also the right thing to do. And we learn about another community, its issues and the botanical aspect of it."

So, in the end, it's all about community and making that community better. And, that, the botanists will tell you, is just plain fun.

-Story and Pictures by Janice Dahl, Great Story!

Taking a close look at a tiny weed, you never stop learning, even after hours of labor during the Botany in Action project.

Bayou Rebirth

Bayou Rebirth's mission focuses on restoring Louisiana's wetlands, and who's history dates back to 2007. Bayou Rebirth has a dedicated staff, relationships with a wide variety of sponsors and partnerships, and a dedicated Board of Directors all working towards preserving and restoring Louisiana's wetlands. See more at: http://www.bayourebirth.org/about-us/#sthash.cIYj05qH.dpuf

In an effort to increase public awareness of coastal land loss and the need for urban resilience to climate change impacts, Bayou Rebirth seeks to bring together, educate, and empower residents of and visitors to South Louisiana through hands-on wetlands restoration and stewardship projects. - See more at: http://www.bayourebirth.org/about-us/mission/#sthash.n0CfPhj3.dpuf

Botany 2013 is proud of the volunteers that helped and donated their time to this very worthy cause.

BSA Science Education News and Notes

BSA Science Education News and Notes is a quarterly update about the BSA's education efforts and the broader education scene. We invite you to submit news items or ideas for future features. Contact: Claire Hemingway, BSA Education Director, at chemingway@botany.org or Marshall Sundberg, PSB Editor, at psb@botany.org.

New and Ongoing Society Efforts

PlantED Digital Library

Do you have a resource for teaching or learning botany to share? Resource Editors J. Phil Gibson and Stokes Baker are pleased to announce a call for submissions to the BSA's digital library. Inquiry activities, data sets, syllabi and images are only a few of the resource types welcome.

PlantED, the BSA's new resource portal, is run in conjunction with companion portals of the Ecological Society of America, the Society for Economic Botany, and the Society for the Study of Evolution. Peer-reviewed resources in PlantED will be searchable across these four portals and included in the National Digital Science Library. Your resource supporting botanical education could reach a wide audience.

If you have resource to contribute, we're here to help you share it. Please visit http://planted.botany.org.

PlantingScience

As PlantingScience comes to the end of its first (but we anticipate not its last) major grant, we are taking stock of impacts and lessons learned. In early planning meetings, the number of scientists willing to volunteer was anticipated to be a potential limiting factor for the project. How exciting it is to report that was a faulty assumption.

The number of scientists offering their time and expertise as online mentors has only grown across the years—now over 800 scientists from diverse career stages and work places. New mentors continue to join the effort to enhance the way secondary school students and their teachers experience science. As important as recruiting new mentors, there is long-lived commitment on the part of many mentors. Of those scientists who have mentored two or more sessions, a phenomenal 6% have mentored 10+ sessions—that's lasting power of 5+ years!

In addition to the opportunity to volunteer as a mentor in any session that fits a scientist's schedule, the program has offered a special opportunity for graduate students and post-doctoral researchers to make a year-long commitment as a member of the Master Plant Science Team (MPST). Since 2006, the Botanical Society of America and the American Society of Plant Biologists have sponsored 127 individuals; the Ecological Society of America starts sponsorship this year. Nine MPST members have served 3+ years—that's significant mentoring experience in early career development!

As scientists concerned with the state of science education, you have shown great dedication. You have also demonstrated skill in helping novice science learners see how science works. In analyzing 170 mentor dialogs between scientists and student teams, we found that mentors promote the idea of scientific community, acculturate and welcome students to it, seek to broker relationships and negotiate expectations for interactions with student teams, and encourage students to connect ideas about science content and process when asking about student ideas (Hemingway and Adams, 2013).

Our hearty thanks to each and every one who has volunteered as a PlantingScience mentor and served as an Master Plant Science Team member thus far. In our effort to recognize your efforts, names in the illustrations are weighted by the number of sessions participated.

Our Hats off to you!

Thank you to the Master Plant Science Teams

Thanks to the 2012-2013 Master Plant Science Team Members, Mon-Ray Shao, Lisa Kanizay, Christine Palmer, Lina Castano-Duque, Molly Hanlon, Mohammad Salehin, Elena Batista Fontenot, Kranthi Mandadi, Mitchell Harkenrider, Jennifer Lind.

Our thanks to the 2013-2013 Master Plant Science Team. The BSA sponsored: Ben Gahagen, Katherine Geist, Klara Scharnagl, Sampurna Sattar, Katie Clark, Evelyn Williams, Angela Rein, Marites Sales, Katie Becklin, Steven Callen, Alan Bowsher, Elizabeth Georgian, Wesley T Beaulieu, Max Jones, Bryan T. Drew, Chris Doffitt, Rhiannon Peery, Rupesh Kariyat. The ASPB sponsored: Susan Bush, Mon-Ray Shao, Lisa Kanizay, Christine Palmer, Lina Castano-Duque, Molly Hanlon, Mohammad Salehin, Elena Batista Fontenot, Kranthi Mandadi, Mitchell Harkenrider, Jennifer Lind

Education in Action at Botany 2013

A Few of the Teaching Session and Poster Highlights

How effective is PowerPoint as an instructional delivery method? How severe is "Plant Blindness" among undergraduate students? What goes into developing a general plant biology lab for distance education? How can you make fake barf for a forensic botany case study? These are some of the questions addressed in talks and posters presented this year at the Teaching Section.

Links to a few resources mentioned in talks and posters:

Secondary Growth Animation—This animation provides cellular, tissue, cross-section, and macroscopic views across five seasons of grow. Hide or show legends.

http://go.ncsu.edu/secondarygrowth

Cornell University Plant Anatomy Collection—This searchable online slide collection of over 8,800 anatomical slides of a wide array of plant parts is available for both teaching and publication. Try the online measurement tool.

http://cupac.bh.cornell.edu

Biology Teaching Assistant Project (BioTAP)—this is a network of individuals interested in enhancing biology graduate teaching assistant professional development. Learn more.

http://www.bio.utk.edu/biotap/

Yes, Bobby, Evolution is Real Symposium

If you missed the selection of interesting talks in the symposium on teaching about evolution, you can catch some of the news and excitement it generated:

The Times Picayune covered the symposium.

http://www.nola.com/education/index.ssf/2013/07/scientists_criticize_creationi.html?utm_content=buffer06b57&utm_source=buffer&utm_medium=twitter&utm_campaign=Buffer

Chris Martine blogged about it in the Huffington Post.

http://www.huffingtonpost.com/dr-chris-martine/the-day-that-botany-took-_b_3703257.html

From Around the Nation

Art and Science Collaborations in Ecological Reflections

Science is a way of knowing; art is a way of knowing. When scientists, artists, and writers come together to explore places of long-term inquiry, their collaborations educate and inspire broad audiences to build a deeper understanding of the natural world. The Ecological Reflections is a network of scientists, artist and writers that grew out of the National Science Foundation (NSF)–funded Long-Term Ecological Research (LTER) program.

"How do we respond as change comes to places we know and love?" is a central question addressed in the Ecological Reflections, which include creative writer/artist residencies, interdisciplinary workshops, and K-12 projects. Art-science collaborations at 11 LTER sites in the continental US, Alaska, and French Polynesia are being showcased at various locations. Attendees at the 2013 or 2012 Ecological Society of America meetings had the pleasure of seeing some featured works first hand. An exhibit is also on display at NSF.

http://www.ecologicalreflections.com

"Last Exit" by Edward Sturr, Konza Prairie.

Unleashing a Decade of Innovation in Plant Science

"*The nation is not prepared for future agricultural challenges*." The final report of the Plant Science Research Summit enlarges the vision and voice to the national calls to action. Five interwoven components are recommended to reimaging the research enterprise to support the agriculture sector: (1) increase the ability to predict plant traits from plant genomes in diverse environments, (2) assemble plant traits in different ways to solve problems, (3) discover, catalog, and utilize plant-derived chemicals, (4) enhance the ability to find answers in a torrent of data, and (5) create a T-training environment for plant science doctoral students.

T-training means to add cross training that prepares students for a wide variety of careers, while retaining disciplinary apprenticeship in a mentor's laboratory and shortening time to degree. The statistic that only one of six PhD biologists becomes tenure-track faculty within five years of obtaining their degrees is only one reason re-imagining graduate training is recommended. Read the full report:

http://plantsummit.files.wordpress.com/2013/07/aspb-final-report-plant-summit-lo-res-web-july-15-2013.pdf

The Power of Partnerships: A Guide from the NSF Graduate Stem Fellows in K12 (GK-12) Program

Although the GK-12 Program is no longer ongoing, the community is encouraged to adopt and expand on the GK-12 approach to foster partnerships between universities and K-12 schools, with graduate fellows as key links. An aim of the recently published guide is to support adoption of best practices of this approach.

http://www.gk12.org/2013/06/10/the-power-of-partnerships-a-guide-from-the-nsf-gk-12-program/

Engaging Students by Emphasizing Botanical Concepts Over Techniques: Innovative Practical Exercises Using Virtual Microscopy.

Bonser, S. P., P. de Permentier, J. Green, G. M. Velan, P. Adam, and R. K. Kumar. 2013. *Journal of Biological Education* 47(2): 123-127.

Virtual microscopy, a technique developed in implemented in many medical schools, allows intro-level students to manipulate magnification and scan images similarly to using a microscopy, but without having to make adjustments of lighting or focus. The authors present data that not only do students prefer virtual slides, but in fact they score statistically better on practical examinations than students using traditional glass slides and microscopes. So how important is the skill of being able to effectively use a microscope? Or perhaps more important, when should this skill be taught to students?

Teaching Botanical Identification to Adults: Experiences of the UK Participatory Science Project 'Open Air Laboratories.'

Stagg, B. and M. Donkin. *Journal of Biological Education* 47(2): 104-110.

Three different methods—dichotomous key, mnemonic word association exercises, and pictorial card games—were compared for learning plant identification by a variety of adult participants ranging from high school dropouts to college graduates. There was no significant difference between techniques for learning or motivation for any of the groups.

A Forgotten Application of the Starch Test.

Hartley, S. M. 2013. *The American Biology Teacher* 75(6): 421-422.

In C4 plants, as explained in this article, only the bundle sheath cells accumulate starch and stain positively with IKI. It is a perfect inquiry lead-in to C4 photosynthesis after students have worked with C3 plants.

The Trouble with Chemical Energy: Why Understanding Bond Energies Requires an Interdisciplinary Systems Approach.

Cooper, M. M. and M. W. Klymkowsky. 2013. *CBE-Life Sciences Education* 12: 306-312.

If you teach that "chemical bonds contain energy that is then released as bonds break," you have to read this article. According to the authors, there are three major reasons why students have difficulty understanding energy: (1) biologists tend to talk about chemical energy in a colloquial, everyday sense, (2) physics and physical sciences explain it from a macroscopic perspective (a ball rolling down a hill), and (3) chemists fail to explicitly link molecular with macroscopic energy ideas. The authors walk through each of these difficulties and present a model for integrating energy concepts throughout the curriculum.

HARVARD UNIVERSITY BULLARD FELLOWSHIPS IN FOREST RESEARCH

Each year Harvard University awards a limited number of Bullard Fellowships to individuals in biological, social, physical and political sciences to promote advanced study, research or integration of subjects pertaining to forested ecosystems. The fellowships, which include stipends up to $40,000, are intended to provide individuals in mid-career with an opportunity to utilize the resources and to interact with personnel in any department within Harvard University in order to develop their own scientific and professional growth. In recent years Bullard Fellows have been associated with the Harvard Forest, Department of Organismic and Evolutionary Biology and the J. F. Kennedy School of Government and have worked in areas of ecology, forest management, policy and conservation. Fellowships are available for periods ranging from six months to one year after September 1. Applications from international scientists, women and minorities are encouraged. Fellowships are not intended for graduate students or recent post-doctoral candidates. Information and application instructions are available on the Harvard Forest web site (http://harvardforest.fas.harvard.edu). Annual deadline for applications is February 1.

AMERICAN PHILOSOPHICAL SOCIETY RESEARCH PROGRAMS

Information and application instructions for all of the Society's programs can be accessed at http://www.amphilsoc.org. Click on the "Grants" tab at the top of the homepage.

INFORMATION ABOUT ALL PROGRAMS

Purpose, Scope

Awards are made for noncommercial research only. The Society makes no grants for academic study or classroom presentation, for travel to conferences, for non-scholarly projects, for assistance with translation, or for the preparation of materials for use by students. The Society does not pay overhead or indirect costs to any institution or costs of publication.

Eligibility

Applicants may be citizens or residents of the United States or American citizen residents abroad. Foreign nationals whose research can only be carried out in the United States are eligible. Grants are made to individuals; institutions are not eligible to apply. Requirements for each program vary.

BRIEF INFORMATION ABOUT INDIVIDUAL PROGRAMS

Franklin Research Grants

Scope

This program of small grants to scholars is intended to support the cost of research leading to publication in all areas of knowledge. The Franklin program is particularly designed to help meet the cost of travel to libraries and archives for research purposes; the purchase of microfilm, photocopies or equivalent research materials; the costs associated with fieldwork; or laboratory research expenses.

Eligibility

Applicants are expected to have a doctorate or to have published work of doctoral character and quality. Ph.D. candidates are not eligible to apply, but the Society is especially interested in supporting the work of young scholars who have recently received the doctorate.

Award

From $1000 to $6000.

Deadlines

October 1, December 1 (December 2 in 2013); notification in January and March.

Lewis and Clark Fund for Exploration and Field Research

Scope

The Lewis and Clark Fund encourages exploratory field studies for the collection of specimens and data and to provide the imaginative stimulus that accompanies direct observation. Applications are invited from disciplines with a large dependence on field studies, such as archeology, anthropology, biology, ecology, geography, geology, linguistics, and paleontology, but grants will not be restricted to these fields.

Eligibility

Grants will be available to doctoral students who wish to participate in field studies for their dissertations or for other purposes. Master's candidates, undergraduates, and postdoctoral fellows are not eligible.

Award

Grants will depend on travel costs but will ordinarily be in the range of several hundred dollars to about $5000.

Deadline

February 1 (February 3 in 2014); notification in May.

Library Resident Research Fellowships

Scope

The Library Resident Research fellowships support research in the Society's collections.

Eligibility

Applicants must demonstrate a need to work in the Society's collections for a minimum of 1 month and a maximum of 3 months. Applicants in any relevant field of scholarship may apply. Candidates whose normal place of residence is farther away than a 75-mile radius of Philadelphia will be given some preference. Applicants do not need to hold the doctorate, although Ph.D. candidates must have passed their preliminary examinations.

Stipend

$2500 per month.

Deadline

March 1 (March 3 in 2014); notification in May.

Contact Information

Questions concerning the Franklin and the Lewis and Clark programs should be directed to Linda Musumeci, Director of Grants and Fellowships, at LMusumeci@amphilsoc.org or 215-440-3429.

Questions concerning the Library Resident Research Fellowships should be directed to Earle Spamer, Library Programs Coordinator, at libfellows@amphilsoc.org or 215-440-3443.

English - Spanish / Spanish – English Dictionary of Botany Now Available

By far the world's largest, most accurate, and most in-depth English-Spanish / Spanish-English work in botany, by Kenneth Allen Hornak (Lexicographer): a wealth of terms compiled from thousands of botanical studies carried out by doctors in their fields.

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A learning gap is filled with plants

Arboretum offers increasingly rare course in their morphology

By Alvin Powell, Harvard Staff Writer

Sam Perez is searching for mutants. But to find them, he has to know what normal looks like.

Perez was among a dozen top botany graduate students and postdoctoral fellows who took an intensive, two-week course in what may be a vanishing discipline, plant morphology, at the Arnold Arboretum this month.

The course, with funding from the National Science Foundation and the Arnold Arboretum, is modeled after intensive, high-level courses in marine science offered by the Woods Hole Oceanographic Institution in Massachusetts and in molecular biology at the Cold Spring Harbor Laboratory in New York, according to William Friedman, arboretum director and Arnold Professor of Organismic and Evolutionary Biology. The course is the first of what will become an annual summer offering in plant organismic biology at the Arboretum.

Plant morphology, which involves understanding the genesis of a plant's entire shape and structure, has been taught less frequently in recent years, shouldered aside by the increased emphasis on genetics and understanding of how a plant's DNA affects its growth and appearance.

"There aren't that many places where the study of the whole organism is very prevalent. It's not a big part of the curriculum," Friedman said. "Zoology, botany, ichthyology, all the '-ologies' have been on the ropes across the world, not just in the U.S. And as faculty who used to study morphology and whole organisms were replaced by genomics people, we've lost the ability to connect genes back to the biology of the organisms themselves."

The dazzling diversity of flowering plants poses a special problem for budding botanists, since particular flower parts, for example, can look quite different in one species than in another. In addition, the use of a very few specific plants as laboratory models—akin to lab rats or fruit flies—has focused what morphological teaching there is on just a handful of species.

Young scientists like Perez have become adept at using the powerful tools of genetics in their studies, but some are finding that their lack of knowledge of plant morphology hinders their work.

Perez, a Michigan State University doctoral student who graduated from Harvard College in 2011, is examining plant mutants, comparing their genomes with normal plants to discover which genes are responsible for the mutated trait to better understand the genetics of the normal trait. He's finding, however, that to identify plants with mutations, he needs a better understanding of normal plant morphology.

"Plant morphology is important to me because I'm studying the development of certain floral structures, but I don't have an understanding of what goes into the development of actual flowers," Perez said.

The course, taught by Pamela Diggle, visiting professor of organismic and evolutionary biology from the University of Colorado, and Peter Endress, professor emeritus of the University of Zurich, was specifically designed to be an intensive experience for participants, Diggle said.

Students are picked up each day at 8 a.m. from their dormitory at Emmanuel College in Boston's Longwood area, and are dropped off after 9 p.m. In between, they have three-hour lectures each morning, followed by lunch, and three hours of laboratory time each afternoon, with discussion sessions, special lectures, and dinner mixed in. Students also gain access to the Arboretum's living collection of more than 15,000 plants spread over 281 acres.

The intensive atmosphere is needed to cover a large amount of ground, said Diggle, who teaches plant morphology at the University of Colorado.

"As fast as I can talk, that's what I can cover," Diggle said. "My feeling is this is a really fundamental area, a common denominator for people working in different areas. … As we've become more specialized in knowledge, the commonality of the organisms is missing, and I think science is suffering for it."

Despite the heavy workload, participants aren't shying away from adding more of their own. Though the course tries to give the students a general knowledge of plant morphology and is not focused on their specific research subjects, the students asked early on whether they could present their research to the group during lunch, one of the few breaks in the day.

"The students are extremely good, extremely motivated," Endress said. "They work more than we expect."

For Kelsey Galimba, a doctoral student from the University of Washington, the long hours haven't been too much to handle. Like Perez, Galimba signed up after finding that gaps in her knowledge of plant morphology were affecting her research. "It's not been nearly as hard as I thought it would be. I don't know if it's because we have a good group or because of the interesting material, but we've all been fine with the hours."

The intensity provides not just an opportunity to cover a lot of ground, Diggle said, but also allows participants to bond, providing the seeds, hopefully, of an informal network that will be part of the lasting effects of the experience.

"My adviser said, 'Josh, go to this because you don't get instruction in plant morphology like this anyplace else,'" said Josh Strable, a doctoral student at Iowa State University. "If you're accepted, it'll be something you'll take with you for the rest of your career."

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Elementary botany: how teachers in one school district teach about plants

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ABSTRACT

Students rarely know as much about plants as animals. Some researchers attribute this to deficiencies in formal education; however, little has been documented about how K-12 teachers approach teaching plant topics. We investigated how elementary teachers in one school district teach about plants. Thirteen K-5 teachers were interviewed. Teachers expressed comfort teaching about plants despite having little botanical training. All used resources beyond the textbook and affiliated activity kit, but activities and topics were repetitive. Teachers said students loved growing plants, but lack of adequate sunlight, water, and space made this difficult. Most would like a garden or greenhouse at school. Results suggest elementary botanical education, at least in this school district, could be improved by providing professional development about plants to supplement preservice education, removing barriers to growing plants in classrooms and outdoors, and developing sequences of plant activities that diversify students' experiences as they advance through the curriculum.

Keywords: curriculum; elementary education; instruction; plants; teachers.

INTRODUCTION

While the last 100 years have significantly increased scientific knowledge about plants, there seems to have been a concomitant decrease in student education about and interest in botany over the same period. The percentage of high schools offering botany classes has decreased from over 50% in the early 1900s to less than 2% in the 1990s (Hershey, 1996). Less than 1% of all students entering college indicate "botany" as their future major (Uno, 1994), and fewer undergraduate institutions are offering botany degrees (Drea, 2011). Both Wandersee (1986) and Kinchin (1999) have documented that K-12 students have less interest in studying about plants compared to animals. Students are also less likely to say that plants are alive as compared to animals, and most students find assigning specific names to plants to be particularly difficult (Wood-Robinson, 1991; Inagaki and Hatano, 2002; Bebbington, 2005; Cooper, 2008; Patrick and Tunnicliffe, 2011). Misconceptions pertaining to plant growth and reproduction are also common in students of all ages (Simpson and Arnold, 1982; Barman et al., 2003; Schussler and Winslow, 2007). This lack of botanical interest and knowledge should be of concern on a planet where the survival of animals, including humans, is dependent on the health and ecosystem services of the green plants that are the foundation of terrestrial life.

Many botanists and educators suggest that student interest in plants has to be carefully fostered from an early age because children are not as inherently interested in plants as they are about animals. Wandersee and Schussler (2001) have argued that humans have a natural visual tendency to be "Plant Blind." Plant characteristics such as their lack of movement and a face, their uniform color and spatial grouping, and the fact that they are typically not harmful result in humans discarding them from their conscious attention. However, visual attention to plants can be increased by educational exposure to them. A nature study in Switzerland showed that a relatively short educational program (averaging 17 hours of instruction) on local flora and fauna for 8- to 16-year-olds significantly increased student knowledge and appreciation of local plants (Lindemann-Matthies, 2005). Thus, instruction about plants in formal education settings should be a critical component of fostering botanical interest and knowledge (Strgar, 2007; Fancovicova, 2011; Ju and Kim, 2011).

Botanists, however, have suggested that primary and secondary school curricula and/or instruction are not facilitating student learning about plants. Evidence from student interviews found that children say they learn more about the names of plants at home (71%) than they do at school (27%) (Tunnicliffe and Reiss, 2000). One possibility for this lack of formal learning about plants is deficiencies in curricula about plants. For instance, Link-Pérez et al. (2010) found that in two major publishing companies' elementary science textbooks, the photographs of animals were captioned with specific names more than 80% of the time (e.g., rhinoceros, five-lined skink), while a third of the photographs of plants were captioned with terms for plant parts (e.g., leaf), life form (e.g., tree), or simply "plant". In the same two textbook series, Schussler et al. (2010) found that the topics presented about animals were more focused on adaptations and whole-organism content while information on plants focused mostly on parts and growth. They also discovered that animal examples were used almost twice as much as plant examples to illustrate content in the textbook series. Overall, these textbooks (which were the same ones used by the teachers in the current study) exhibited differences in the presentation of plant and animal content that could help to explain deficiencies in student understanding about plants, particularly in comparison to their understanding of animals. These challenges for botanical education are likely compounded by federal accountability mandates in recent years that emphasized a focus on language arts and mathematics in primary grades, leaving limited time for science instruction (Marx and Harris, 2006; Griffith and Scharmann, 2008).

On the other hand, curriculum is only one aspect of the classroom. Ultimately, it is the teachers themselves who determine what actually occurs in the classroom setting. Even the best botany curriculum in the world is useless if teachers choose not to use it, as pointed out by Hershey (1996); by the same token, a good teacher can ameliorate a deficient curriculum by conveying their own understanding of a topic (Darling-Hammond, 2000). Some have questioned, however, whether teachers who lack an understanding about plants would be able to convey an interest in or knowledge about plants to students (Uno, 1994; Hershey, 1996).

Studies of elementary teacher confidence in teaching science indicate that most elementary teachers are literacy, and not science, specialists (Flick, 1995; Akerson, Flick, and Lederman, 2000). Confidence in teaching science has been found to be correlated with personal experiences in learning science (Jarrett, 1999), the number of science content courses completed (Jarrett, 1999; Yilmaz-Tuzun, 2008), and the amount of professional development (Murphy, Neil, and Beggs, 2007). With gaps in content knowledge of a subject, science teachers are thought to be less confident in teaching the subject (Abell and Roth, 1992; Dickinson et al., 1997; Akerson and Flanigan, 2000), may fail to direct the learning experience appropriately (Osborne and Simon, 1996), and may revert to several coping mechanisms identified by Harlen and Holroyd (1997), including teaching a minimal amount of the subject, relying on prepared kits or outside-developed lessons with step-by-step instructions that students can follow, emphasizing expository teaching while minimizing discussions, using only the simplest hands-on activities, and looking to outside experts and colleagues for assistance. Studies of confidence in teaching science have generally found that teachers are more confident teaching biology than chemistry or physics, and in one case, were even found to be most confident teaching about the topic of the flowering plant (Murphy, Neil, and Beggs, 2007). Increased professional development and confidence, however, does not necessarily correlate to correct understanding of a topic, as indicated by Jarvis and Pell (2004).

There is a large gap in the research literature about how plant information is presented in elementary and secondary schools. In particular, there has been little but speculation about what science teachers know about plants, where they learned their information, how comfortable they feel teaching about plants, the resources they use, and the classroom practices they use to engage their students in learning about plants. Yet even in the absence of research, several scholars have suggested that teachers' lack of botanical content knowledge is affecting teaching about plants in formal education settings (Uno, 1994; Hershey, 1996).

The goal of this study was to investigate how elementary teachers in one school district approach teaching about plants. The focus was strictly on capturing teachers' perceptions and not their actual classroom practices or the students' experience. Therefore, this study documents teachers' self-reported experiences in teaching about plants, in order to assess their comfort level and experiences in botanical instruction and build the foundation for further research on this topic. Data were collected through the use of one-on-one interviews. The specific objectives in data collection were to answer the following questions:

- How do teachers feel about teaching plant content?
- What types of activities are used to teach about plants?
- How do students react to lessons about plants?
- Is there anything teachers need to help them teach about plants?

Common themes identified from these teachers' experiences were then used to make suggestions for the improvement of botany teaching and learning in the context of primary science education in this particular school district, and then to infer how these recommendations may apply more broadly to other school districts and teachers.

METHODS

This study focused on elementary school instruction about plants because these are some of the first formal experiences students have with plants. It was also done simultaneously with a school system-university collaborative plant growth and reproduction experiment (utilizing Wisconsin Fast Plants®) for the fourth-grade teachers in the district (Schussler and Winslow, 2007). The school district is centered in the Midwestern university town where the study was conducted. The area is a suburban / rural mix, with students coming from the local university town of approximately 20,000 residents and 18,000 undergraduate and graduate students, as well as surrounding areas comprised of a significant corn and soybean farming community.

In the year and state in which the study was conducted (Ohio), plants were taught as part of the curriculum in kindergarten (living / non-living, plant and animal features and habitats), first grade (plant and animal growth needs), second grade (survival needs, structures, habitats, seasonal changes), fourth grade (life cycles, structure / function, classification, interactions with other organisms), and fifth grade (plants as producers, food webs), to varying extents. As mentioned in the introduction, an analysis of the national science textbook series used in this school district identified differences between how plant and animal information is presented that potentially decreases student exposure to certain types of plant information (Link-Pérez et al., 2010; Schussler et al., 2010).

In May 2006, elementary science teachers (kindergarten through fifth grade) from the three elementary schools in the local school district (comprising approximately 3000 K-12 students, with approximately 60 K-5 classroom teachers) were given information about this study by the science instructional leader on behalf of the researchers. The information was presented in writing and included a form teachers could fill out if they were willing to be interviewed regarding their experiences teaching about plants. Participants were told that they would receive $25 in books or resources to compensate them for the time they spent doing the interview. Seventeen teachers volunteered to participate in the study; all of them were contacted, and 13 interviews were subsequently scheduled and completed. Four of the teachers either did not get back to the researcher about scheduling or decided not to participate after hearing more about the study.

All 13 participants were female, and their K-12 teaching experience ranged from 2 to 30 years (Table 1). With two exceptions (Rebecca and Allison; all participant names are pseudonyms), all teachers had taught their entire careers in elementary grades. Two of the teachers (Sherry and Christine) were initially trained for special education instruction. Eleven of the teachers considered themselves experienced science teachers; one (Christine) had just completed her first year of teaching science, and one (Martha) was about to teach science for the first time.

Participant (pseudonym)	Grade being taught	Years experience
Whitney	Kindergarten	12
Martha	Kindergarten	2
Vanessa	First	15
Patricia	First	25
Kate	Third	17
Rebecca	Third	30
Carol	Third	20
Sherry	Fourth	19
Bethany	Fourth	9
Tessa	Fourth	10
Christine	Fourth	30
Samantha	Fourth	19
Allison	Fifth	20

Table 1. Participant years of experience and grade teaching in upcoming year.

Interviews were semi-structured (Hatch, 2002) and generally followed the interview guide shown in Table 2. The interview contained three major areas of discussion: teacher background (grades and subjects they have taught, for how long), their experiences teaching about science in general, and their perspectives regarding teaching about plants. The "teaching about plants" questions explored how teachers felt about teaching plant content, the resources they used when teaching about plants, the activities they have done, obstacles they faced, students' reactions to plants, and what the teachers wished they could do to teach about plants. Teachers were given the opportunity to choose the interview location; about half of the interviews occurred at the school where the teacher worked, and about half occurred at the teacher's house. The second author conducted all of the interviews. Each interview was audio-recorded, with permission of the participant, and lasted from 20 to 65 minutes.

Each interview was fully transcribed and the resulting transcript was subjected to inductive qualitative analysis. No pre-determined themes or codes guided the analysis; the researchers, instead, used the data to inform their analysis and the creation of themes (Corbin and Strauss, 1990). Two researchers, each working independently, read and took notes from each participant's interview. Each researcher then read and re-read the notes, identifying recurrent ideas that emerged from the data. The researchers then met and discussed these recurrent ideas until a preliminary consensus was reached about themes. These themes were then used for a second round of qualitative analysis using the software program NVivo (version 7.0, QSR International). One of the researchers identified and saved portions of the interviews that supported or did not support each of the preliminary themes. The researchers then examined the evidence for each theme and eliminated themes that were not supported by a majority of the participants.

These procedures were approved by the institutions' review board for human subjects research; all procedures for the ethical collection and use of information from human subjects were followed.

RESULTS

Themes from the teachers' responses were categorized according to each of the four research questions of the project: how teachers feel about teaching plant content, the activities used to teach about plants, student reaction to plant activities, and what teachers need in order to teach about plants. Table 3 provides a summary of the themes for each of the research questions.

No training? No problem!—When the teachers were asked to reflect about their feelings regarding teaching about plants, two themes emerged: "lack of training" and "comfort teaching about plants." Nine of the teachers could not recall learning anything about plants during their preservice education. Two had taken a botany course, and two recalled learning a little about plants or planning a plant lesson as part of their science methods course. Bethany said, "I don't remember specifically doing that in any of my classes…I don't remember anything specifically

Background

- How long have you been teaching?
- What grades have you taught over your career?
- What subjects have you taught, and what will you teach this year?
- What percent of your teaching time is spent teaching science (rough estimate)?

Teaching Science

- As compared to teaching other subjects, how do you feel about teaching science—like it, love it, think it's OK, etc.?
- Do you feel your teacher training prepared you to effectively teach about science? Explain.
- What are your favorite and least favorite science topics you teach about?

Teaching About Plants

- Do you feel your teacher training prepared you to teach about plants? Explain.
- Relative to other science topics, how comfortable do you feel teaching about plants?
- What sorts of obstacles, if any, do you encounter when teaching about plants (things that make teaching about plants difficult in the classroom)?
- Are you personally interested in plants? (Do you grow plants, read about them?)
- What resources do you use when teaching about plants (books, kits, supplies, other teachers, etc.)? Do you have a favorite?
- Compared to other science topics, do you have a harder or less hard time finding good resources to use when teaching about plants?
- What are some examples of lessons you use to teach about plants? What has really worked and what has not?
- Do you ever go outdoors to teach about plants?
- As compared to other topics, how do your students react when you teach about plants? (excited, not excited, etc.)
- Is there anything about plants that you've noticed your students are particularly interested in?
- If I had big grant money to spend on improving instruction about plants in the school district, what would you tell me to do?
- Is there anything else you would like to add?

Table 2. Interview questions.

about plants." Allison, in response to whether she had learned about plants during her preservice training, said, "No. None. No…. I had to do a lot of the, um, you know, you do the work at home to make sure that you know what you're talking about [to prepare for classroom instruction]." Patricia recalls, "Honestly, the only thing I remember is having to diagram and label parts of a plant. But I can't, — oh, and I guess we went into different types of leaves." Similarly, Martha said,

> "One thing I remember is he [the instructor] had, um, one of the, I don't know what kind of lights they were, but a light you have inside that helps plants grow. Um, so he had one of those and we had, um, seeds that we planted in baggies and had them sprout and we put them in the dirt and had them grow. So I know he had us do that. I don't remember necessarily anything else in particular that we learned. But I do remember doing that."

Many of the teachers had a very positive feeling about their preservice science training in general, despite the fact that the majority had none, or very little, botanical training.

Undeterred by their lack of specific training or background related to plants, 11 of the 13 teachers reported feeling "comfortable," or even "confident," when it comes to teaching about plants in their classrooms. One felt "medium" about it, and one stated she was "not confident." When asked about her comfort level when teaching about plants, Bethany said,

> "It—because it's, like I said, something you can read about and, it's pretty straightforward to me…And it is something you learn a lot in

Category defined by research question	Theme
Feelings about teaching plant content	Lack of training Comfort teaching about plants
Types of activities used to teach about plants	Supplementing the standard curriculum Repetition of activities
Students' reactions to lessons about plants	Students love to grow plants Students' excitement is short-lived
Impediments/needs for teaching about plants	Logistical growth problems A space to grow plants

Table 3. A summary of major themes emerging from the teacher interviews, grouped according to the categories defined by the four research questions.

> school…you always are doing plants as you're growing up during school, so it was a little more of a comfort level. And, nothing changes really in plants—a plant's a plant's a plant. It's gonna be the same ten years from now. So there's a little more comfort level there."

Tessa, when asked to compare her comfort level teaching about plants relative to other science topics said,

> "I'd probably put it farther toward the front, mostly because of my personal background. My parents were farmers… I always worked with plants. I'm not saying I'm great with them, but I understand, you know, how to work with them and have done gardening and stuff. So I'm a little bit more familiar with plants."

In a similar vein, Samantha attributed her comfort to her personal love of plants:

> "Um, I feel more comfortable teaching about plants than some of the other topics—the matter and the energy, more of the physical sciences… I just, I'm more comfortable with plants primarily because I love plants."

Other teachers expressed that once they taught plants for a year, they were able to gain the necessary content knowledge to feel comfortable teaching about them again. Sherry indicated this when she stated,

> "If you had asked before this school year… I would say I did not feel very knowledgeable about plants. I felt like I was always grabbing… some kind of curriculum guide to look up what I needed to look up for myself before I could teach it to the kids…. Now after this school year, I feel like we did so much more with plants that I feel more comfortable with it now. I think I, I mean I know I'm not the expert yet…"

Three of the teachers had a personal interest in gardening that they used to inform their instruction about plants. Two stated that the plant activities were so "redundant" or "simple" that a lack of training was not an impediment to their teaching. Overall, there was no evidence that the teachers felt that a lack of plant training was an obstacle to their teaching about plants.

Not lima beans again!—Two themes emerged from the portion of the interviews in which teachers reflected on the types of activities used to teach about plants in their classrooms: "supplementing the standard curriculum" and "repetition of activities". The school district provides a nationally syndicated textbook (modified for each state) and associated activity kit that teachers use when teaching science. However, all 13 teachers reported supplementing these resources when they taught about plants. As Patricia said, "I think all of us probably use the kits, at least to a certain extent. And then, we, you know, use our other materials to supplement with." When asked whether it was more or less difficult to find resources about plants as compared to other topics, three said it was the same, three said it was harder, and four said it was easier. Easier to find, however, didn't mean the teachers liked the quality of the activities; Allison articulated this when she said, "I think it's pretty easy to find things. Although, I am not always real thrilled with what I find because some of the stuff is so specific." Teachers mentioned that they use the Internet, DVDs, and local plant experts as additional resources. More significantly, 12 of the 13 teachers said they use children's books to supplement their plant lessons. Vanessa said, "[Children's literature] That's the biggest thing… That's how I would start almost all my lessons, with a book or with some kind of an idea from a book." Martha mentioned the local library as a resource: "Lane's [Lane Library] is really good because they will put collections together for you if you tell them what you want." Whitney mentioned, "And we are supplementing a lot with literature." This heavy reliance on children's literature is likely a reflection of a district initiative to integrate reading into science as a mechanism to prepare students for statewide reading testing.

An overall repetition in the activities used to teach about plants in the elementary grades was a strong theme that emerged from the interviews. Although only three of the teachers directly referenced the repetitive nature of the plant activities, four of the teachers mentioned an experiment where students grew plants in the light and dark, three mentioned an activity with dye and celery, and eight mentioned growing or using lima beans. Sherry acknowledged the problem of students knowing the outcome of these repetitive activities but didn't know how else to demonstrate some of the basic botanical principles.

> "If they already know what's going to happen before you do it…I'm looking for something else to do that will show them, and I think that's really hard. With the plants especially, it's hard to find another way to show them that the plant is going to die if the plant doesn't have any light."

In many cases, the activities they were using were so repetitive that teachers mentioned the dismay that their students felt when doing these activities. Sherry explained,

> "Um, they do the, the old celery and the blue dye and the red dye thing… And they [said], 'Oh! We did this last year! And we did it in second grade too!'"

Allison, who teaches fifth grade, also commented on her students' reactions to growing lima beans:

> "So by the time you get them in fifth grade they'd be like, 'We're not growing beans, are we?' 'Yes we're growing beans again this year!' So that was kind of a, you know, even though you've taught them, you did other things with the beans, but there wasn't a lot of excitement there. At that point because they've done it for every year."

Bethany attributed some of these struggles to limited budgets in the schools, saying,

> "And you're kind of limited money-wise, you know, you're always growing like the lima beans… and that's why Fast Plants, again, were fun, because it was something different. I mean, they've all grown a lima bean, and [inaudible], alfalfa sprouts, you know."

Overall, there was a striking lack of diversity among the activities teachers mentioned doing in their classrooms. In some cases the teachers were aware of this repetition, but others seemed to be unaware that students might find these activities redundant.

Planting excitement—Teachers were also asked to discuss how students reacted to the plant lessons. From these discussions, two themes emerged, one of which is "students love to grow plants". Nine of the teachers, even if they thought students were not that excited about plants in general, admitted that planting a seed and watching it grow was exciting to their students. Kate said,

> "Any time they can grow something themselves, that is just 'It'… Oh, yeah. They would, they, I'm sorry I can't do it [have students grow things], because growing something in the classroom is probably one of their favorite things to do."

Carol commented, "What makes them excited is putting a seed in dirt and two days later, it's coming up. And then, if it gets a flower—oh, my gosh! You'd have thought they had won the lottery!" Whitney had her kindergarten students grow their own lawn grass and expressed the ownership the students felt from growing their plants.

> "And they take their grass home and they plant it in a special place and some of the kids will still tell me, 'My grass is right there in the corner by my house—see! That's my grass, right there!' Cracks me up."

Despite the initial excitement that teachers expressed the students felt about growing plants, a second theme emerged: "student excitement about growing plants is short-lived." Teachers expressed that student excitement about plants (even their growth) was hard to maintain, particularly when doing a longer-term activity. Teachers often observed their students go through an initial excitement followed by a letdown. Sherry said, "My students this year really liked anything we did with plants… But it got old fast." Christine reflected on a project that held student attention better because the plants grew so quickly:

> "Y'know, any toy has to do something, it just can't sit there, and so I think that was the one reason with the Fast Plants that … the first day nothing happened, the second day nothing happened, and then all of a sudden "WOW" there's these green things. That kept them going. Again, attention spans. You have to have something that is going to keep them [interested], or you're going to lose them totally… you need something that is like "look at that, look what happens here."

This excitement to grow plants coupled with the quick loss of enthusiasm by students may help to explain why there is a redundancy of activities such as germinating lima beans, an activity which provides the quick and relatively easy thrill of germination to students.

Growing, growing, groan!—When asked about what they wished they had to teach about plants, two themes emerged: "logistical growth problems" and "a space to grow plants". Eight of the teachers expressed frustration with their classrooms that lacked sufficient light, space, or water sources and indicated that this limited their abilities to grow plants in their classroom. Kate commented about the lack of growth requirements for plants such as water and sunlight.

> "I think teaching plants is very hard. The curriculum is in the winter…No water, no sunlight—it's really a challenge… I would say that, of all the topics in science that I can think of, that's probably the most difficult to try and teach [because of the physical barriers/obstacles]."

Patricia also mentioned the lack of sunlight, saying, "We actually don't get real good sunlight in with these windows that we have. So, when you depend on sunlight for some of your things, it's kind of hard." Samantha mentioned that for her classroom, space was the major limitation.

> "Now as you can see in here, I have very little space I could put plants in front of windows. … So, I will, you know, I'll hang a plant here and I'll put a plant there, but in terms of having kids grow their own it's really hard."

Allison explained the climatological challenges of trying to grow plants in a temporary classroom.

> "So, like, I was in the trailer. So, in the—if you put plants by the window, it would get so hot that they would die in the trailer. I mean, it was just awful. Even if you had the air conditioner on, but then you had to remember to put the heat on at night cause the trailers would cool down. It was really hard."

When asked whether they ever took students outside to view plants, most teachers indicated that an environmental educator contracted by the district led nature walks with the students but that these excursions rarely focused on plants.

When asked what would help them be able to do a better job of teaching about plants, 11 of the teachers wanted a dedicated space where they could grow plants. Sherry said,

> "Some schools have little greenhouses… I just think it would be awesome if we had a greenhouse to use with our kids in fourth and fifth grade where they could grow things other than just little beans. But having like a vegetable garden or an herb garden. They would get exposed to different kind of plants that they had not been exposed to."

Kate agreed, saying, "You'd have a garden. Or you'd have a greenhouse. That's what you'd do. I mean, logically." Rebecca saw the value not only of having a garden, but also of integrating a community project, while focusing on the life cycle of the plants as well.

> "Have a garden, I think, at the school. That the kids would take care of and, and see the whole life cycle kind of thing, and then, you know, use the plants to sell at like a Farmer's Market."

There seemed to be a consensus that live plants, and a wider diversity of plants, are needed for effective teaching about plants, but that the barriers to growing them in the classroom made this too difficult to achieve.

Discussion

The overall goal of this project was to investigate, using interviews, how elementary teachers in one local school district perceived teaching about plants. There are several positive aspects about teaching plant topics that arose from these interviews. First, teachers expressed that they are comfortable teaching the plant-focused content and all went beyond just the textbook and associated activity kit when presenting information about plants. The teachers are taking their own initiative to fill gaps in their content knowledge and to find additional resources to use when teaching about plants. In particular they are linking reading activities to student learning about plants, although they may be doing this as a result of mandated state curriculum testing. Despite logistical obstacles to growing plants in the classroom, the teachers do bring plants into the classroom and at a minimum expose students to the excitement of germinating a seed and watching it grow. The teachers in this study are making a concerted effort to get students excited about plants.

However, several concerns regarding teaching about plants also arose from this study. Almost all the teachers are presenting information about plants with no recollection of any training specific to plants during their preservice education. Several of the teachers were not concerned about their lack of botanical training because they mentioned that it is easy to read a few books and pick up the content. This could imply that the plant content they are teaching is not very in-depth; the redundant activities the teachers mentioned seem to support this speculation. There was also little evidence from the interviews of any instructional objectives beyond plant parts or growth, which is also consistent with the findings of Schussler et al. (2010) that the science textbooks used in this district limited botanical content mainly to the topic of plant parts, in contrast to animal content that extended to animal adaptations, needs, and diversity. Taken together, these results might suggest that although teachers are supplementing text information, they are not adding instruction that goes far beyond the textbook. Further studies are needed, however, regarding actual classroom instructional practices, student learning, and effects of professional development and classroom experience on instruction before broader conclusions can be made.

Many teachers mentioned that they integrate science trade books into their lessons about plants. Integration of trade books into science lessons was promoted because state testing focused on reading and not science in the year this study was conducted (J. Winslow, personal communication; Marx and Harris, 2006). Although teachers were excited about the availability of the science trade books for their botany lessons, several found it challenging to judge a book's quality; as expressed by Martha, "I don't feel comfortable knowing, um, what's a good science trade book and what's not. At this point, anything is better than nothing." A study identifying many incomplete and unexplained representations of plant life cycles in the science trade books available at the same local library serving this school district (Schussler, 2008; also see Hershey, 1996) suggests, however, that these books are not a panacea for classroom botany instruction. Teachers need enough knowledge about plants to identify and supplement incorrect information in the books, but it is unknown if teachers in this district recognized this issue. One role botanists can play in school instruction is to help teachers identify appropriate and inappropriate science trade books about plants, and provide supplemental information as needed.

Teachers reported that students are most excited when they get to grow plants in the classroom. However, the interviews suggest that most of their germination experiences are with bean seeds. Since students quickly lose interest in plants, it seems prudent to find new classroom plants for teachers to use (e.g., Amaryllis or Chia plants; Hershey, 2002; Conover, 2011). Diversity in available plants could help to maintain student excitement and prevent them from knowing what will happen (as several teachers reported hearing from the students). It also can be inferred from the interviews that students rarely get an opportunity to grow a plant through its entire life cycle. Teachers reported that a new program using Wisconsin Fast Plants®, introduced in the schools the year of these interviews, was very successful because the plants changed quickly enough to keep students' attention and they got to see the flowers and fruits in a relatively short time period (Schussler and Winslow, 2007).

When asked what they would like to have available to teach about plants, teachers overwhelmingly focused on things that would help in teaching about cultivated plants: greenhouses and gardens. Given that at least two of the three schools had associated school natural areas, it seems clear that teachers want a diversity of plants available to them, but they prefer to work with plants in a controlled environment (greenhouse or garden) rather than utilizing nature. Several researchers have previously reported on perceived barriers to outdoor learning, including lack of natural areas to use, health and safety concerns, attitudes, weather, time constraints, and acceptable child-to-adult ratios, among others (Dillon et al., 2006; Waite, 2010, 2011; Passy, 2012; Carrier, Tugurian, and Thomson, 2013). It also seems that the teachers in this study take a product-centered approach to teaching about plants, with the focus being on how plants are useful to humans rather than on how plants are a part of nature. Christine articulated this when she stated,

> "What about an organic garden? ... A functional type where we, you would grow cantaloupes or gourds or something. So that you could maybe even not sell it, but at least use that in the classroom making [a] bird feeder from gourds. I mean, using the products to, to, show the kids—or at least I would think—that plants have a purpose in our world. Not just because, 'oh it looks pretty' or 'I eat corn.' That kind of stuff… Here's the whole process of 'we've planted a seed and we have this product, what do we wanna do with this product?'"

Samantha described an activity that also revealed a product-centered approach toward teaching about plants: "I always have them kind of list all the plants they know, they can come up with. And I have them do it on a chart with plants that are food, plants that are landscape or decoration, and plants that are made into something else." This educational focus on human dependence on plant products may also help to explain why teachers would favor a garden or greenhouse to support instruction, versus nature.

Despite teachers' claims of comfort in teaching about plants, coping mechanisms identified by Harlen and Holroyd (1997), such as placing a reliance on outside-developed lessons, avoiding all but the simplest hands-on activities, and seeking assistance from outside experts and colleagues, seemed to be in place. This leads us to speculate that teachers are comfortable teaching the most basic plant information, such as parts and growth needs, but are feeling discomfort because of a lack of textbook support and personal understanding related to plant topics such as reproduction, identification, diversity, or adaptations. The consequence of this discomfort—a plant curriculum that is unchallenging and repetitive—could potentially result in students in this district lacking interest in and knowledge about plants, as many other children across the nation demonstrate (Baird, 1984; Wandersee, 1986; Kinchin, 1999; Patrick, 2011).

Although our findings are limited to teachers in one local school district and may not be representative of teachers as a whole, or only perhaps representative of teachers in the same type of regional school district, we include broader recommendations so that others might consider whether these practices would improve botanical instruction in their own school districts. Given the lack of preservice professional development and the redundancy in the plant science curriculum in this school district, significant work needs to be done in teacher training and curriculum development to help teachers teach about plants in the classroom. Professional development about plants would provide teachers an opportunity to reflect on the current curriculum and practice, and may lead to pacing of curriculum activities to reduce redundancy. Apparent throughout the interviews we conducted was a lack of teachers' reflection about the current status of teaching about plants in their district. Many teachers admitted they had never thought about these issues previously. When asked what sort of activity or "cool thing about plants" they thought would get their students excited about plants, some teachers had no idea, underscoring how important it is for plant scientists and members of botanical societies to engage in community outreach (or programs such as PlantingScience; Hemingway et al., 2011).

A good starting point for outreach activities would be to conduct teacher interviews similar to those in this study to determine how the plant science community can help teachers improve botanical education in their school districts. Interviewing teachers may also lead to collaborative activities where plant scientists team up with elementary teachers to implement some of the interesting plant activities available in the teaching literature (Allen, 2004; Digiovanni, 2010; Mallory, 2011). Partnering with botanical experts in such a way may alleviate some of the fear involved in trying something unfamiliar. Steps should also be taken to help teachers review science trade books and provide students exposure to a variety of plant life, either through field trips to plant nurseries, arboretums, or botanical gardens/conservatories (Keppler and Schussler, 2010), or by obtaining more diverse plants for their classrooms. These steps may begin to open the eyes of teachers and students to the more diverse, more exciting, more intricate world of plants that lies beyond the bean seed.

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A Navigation Guide to Cyberinfrastructure Tools for Botanical and Lichenological Systematics Research

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ABSTRACT

In this paper we describe a navigation guide to the frontiers of cyberinfrastructure for systematic research of plants and lichens. We define this term as it applies to systematics and provide links to resources that can assist the many stages of botanical and lichenological systematic research projects. This guide specifically addresses the concerns of new graduate students, although it should be useful to established researchers as well as interdisciplinary researchers who have an interest in systematics. Included in this paper are links and descriptions of 131 websites distributed in 15 categories. We encourage additions to the curated electronic form of this guide, http://www.botany.org/students_corner/systematics_resources.php, as a means of developing an up-to-date community-driven resource that will assist beginning and established systematic researchers worldwide.

Key words: cyberinfrastructure; internet resources; lichenological systematics; botanical systematics; student resources

The field of systematics has grown to incorporate a bewildering array of internet-based sources of data, from archived resources that were previously only available in physical form (e.g., rare floras, museum specimens, printed datasets) to newly generated molecular genetic and genomic datasets (Harrison and Kidner, 2011). Coincident with the increased availability of such open-access data has been the advent of cyberinfrastructure tools that not only speed systematic analysis of these data but also promote collaborative and interdisciplinary research. What is perhaps most striking about the development of these resources besides their ever-increasing scope and depth is their accessibility, which has "flattened" the field of systematics to some extent. Resources that were previously only available to students and researchers at large research institutions are now more freely accessible to all. An open question is how best to marshal these resources to enhance the study of biodiversity and raise support for systematic research, especially in light of the ongoing extinction crisis and dwindling institutional support for taxonomic expertise.

Cyberinfrastructure tools and their synergistic effects within the field of systematics have been generated within the US in part as a consequence of multimillion-dollar funding initiatives by the National Science Foundation's (NSF) Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21) and Software Infrastructure for Sustained Innovation (SI2). In 2003, the NSF charged a Blue Ribbon Panel with exploring challenges, opportunities, and trends in science cyberinfrastructure. This panel prepared a document that describes cyberinfrastructure priorities in science and engineering, but perhaps more importantly defines the term as "infrastructure based upon distributed computer, information, and communication technology... [and] we could say that cyberinfrastructure is required for a knowledge economy" (NSF, 2003). In much the same way that traditional infrastructure such as roads, bridges, and other structural developments allow for an improved flow of goods, people, and services, cyberinfrastructure lays the foundation for the transmission of information across the research community. Cyberinfrastructure can consist of online data storage, data exchanges, and distributed computing facilities that support remote analysis of data.

The opportunities and challenges of new research emerging from this scientific cyberinfrastructure have received considerable attention. For example, a recent issue of Science titled, “Dealing with data,” focused on these issues in depth (Science Staff, 2011). However, there is no navigation guide to the cyberinfrastructure tools for botanical and lichenological systematics researchers in this new era of “Big Data”. This deficit is certainly a consequence of the constantly evolving landscape of internet resources, as any guide would be destined to be out of date by the time it was published and could never be fully comprehensive. Other Internet databases for botanical resources (e.g., the Internet Directory of Botany; http://www.botany.net/IDB/ and Botany online; http://www.biologie.uni-hamburg.de/b-online/e00/frame.htm) contain an overwhelming number of links, many of which are no longer active and do not distinguish resources by subdiscipline, such as systematics.

Beginning researchers often confront the online frontier alone and established researchers cannot be certain that they are fully utilizing all available resources. In our experience, locating relevant cyberinfrastructure tools or becoming aware of new ones relies on a substantial element of kismet, even after consulting internet search engines, bibliographic databases, and colleagues. Even the most savvy explorer may have difficulty determining whether some tools are more appropriate than others for a particular task or if they provide high-quality results. Moreover, we have encountered examples of functional redundancy among tools that may represent an unnecessary duplication of effort, which could have been avoided had there been even a partial guide to pre-existing resources.

If one of the goals of cyberinfrastructure is to expedite and improve scientific research, systematists must be able to navigate this wealth of resources more effectively. To date, we have found only one existing guide to web-based systematics tools. This resource is operated and maintained through the Entomological Society of America and its content is specific to entomological research (Shockley, 2009, available at http://www.entsoc.org/resources/Systematics_Resources). Other resources include an annual “Database Issue” published through the journal Nucleic Acids Research that provides a listing and brief description of new or updated molecular databases each year (see Galperin and Fernández-Suárez, 2011). Several other cyberinfrastructure guides have been published in peer-reviewed journals recently with the intent of assisting researchers in using data-sharing tools or other networked technologies; however, the scope of these publications is often narrow in focus (i.e., Huttenhower and Hofmann, 2010).

To address the need for a resource guide to cyberinfrastructure tools in plant and lichen systematics, we have compiled a list of web resources using several criteria. We recognize that there are numerous taxon-specific web resources, but due to the sheer volume of such resources we have opted to exclude taxon-specific tools from this guide. We selected online resources related to plants and lichens that are broad or introductory in scope. We have also included resources that cover general systematics research methods. Finally, we limited our selection of resources to those pertinent to US researchers, due to our familiarity with such resources, but also included some well-known international resources that may have broader appeal. We welcome the contribution of other resources we may have overlooked, especially if they fit the criteria of general utility to the systematics research community. These can be contributed to the online version of this paper hosted by the Botanical Society of America: http://www.botany.org/students_corner/systematics_resources.php. One particular strength of an online version of this guide is that it may be curated continuously as new resources become available and others become obsolete. The categories we have established for our internet resources follow a hypothetical workflow new graduate students might want to pursue as they explore and develop a research project in systematics.

We have developed a curated navigation guide for 15 categories of internet resources that will be relevant to beginning plant and lichenological researchers, although established researchers and systematists of other taxa should find the list useful. For each category, we have provided a list of links to individual resources with a brief description of their content and utility. These categories reflect the stages of being a new graduate student; therefore, we start with sections to help the student get the process started, such as consulting (1) **Checklists** and (2) **Visual and other Multimedia**. We follow these introductory resources with categories that can help students gather data already available online, such as (3) **General Plant and Lichen Biodiversity** and (4) **Nomenclatural Resources**. Other resources described below emphasize methods of generating new data in (5) **Collections and Collections Management**, (6) **Fieldwork**

and Permitting, and (7) **Laboratory Protocols**. We continue with suggestions on how and where to get training with (8) **Courses, Workshops, and Guides** and another important part of graduate student life, learning the process of applying for grants under (9) **Funding**. We carry on with suggestions of resources that will help students to analyze their data, such as (10) **Computing**, (11) **Molecular and Phylogenetic Databases**, and (12) **Geographic Information Systems (GIS) and Maps**. After that, we identify resources to assist students with networking and learning about their profession in (13) **Professional Societies**, and (14) **Social Networking.** Finally, we have discussed some relevant resources for obtaining a job in (15) **Employment and Career Development**. Each of these categories has been selected because it represents an important concern for beginning researchers, and we preface each category with an example of typical questions that may occur to new graduate students. Some categories are noticeably absent, such as a section on how to improve teaching skills and where to find teaching materials, as we feel such categories are beyond the scope of this effort.

As a static list of web-links, this guide's lasting value is admittedly ephemeral and as the product of several individual's efforts, it is neither comprehensive nor claims to be authoritative. Moreover, we urge a sense of critical skepticism in using data or services from any internet site as errors can and do occur in their creation. As always, it is good practice to verify the source of the information and, if errors are found, to contact the site administrator with corrections. It is our hope that the electronic form of this guide hosted by the Botanical Society of America, http://www.botany.org/students_corner/systematics_resources.php, will become the basis of a curated, community-driven resource for all botanical and lichenological systematists, as well as a means of welcoming new students into the era of Big Data.

"What taxa might be present at my study site?"

1. Checklists—These lists describe which species are present in a certain locality but can also reveal erroneous records of taxa or the significant absence of others. Checklists for a given region are not static, since species occurrences do change over time. Checklists can also be used to develop hypotheses about ecological interactions and biographical histories of taxa and to refine taxon distribution maps.

Catalogue of Life (CoL):

http://www.catalogueoflife.org/

Catalogue of Life is a partnership linked with several other important projects related to biodiversity (such as GBIF and EOL, described below) and aims to create an integrated checklist of all living organisms. There are 1.3 millions species included already, about 70% of known species. CoL can be used to look up a species' taxonomy and to compile regional checklists.

Checklists of Lichens and Lichenicolous Fungi:

http://www.biologie.uni-hamburg.de/checklists/lichens/portalpages/portalpage_checklists_switch.htm

This website hosts checklists of lichens worldwide. It also includes information about collectors, the general diversity of lichens, and assessments of known species in several countries. The resource is maintained by contributing lichenologists from around the world.

eFloras:

http://efloras.org

eFloras provides a searchable database of regional floras, including checklists, interactive keys, image galleries, and herbarium records. eFloras can be a powerful tool for learning about particular taxa in a given study site or geographic region.

Kew World Checklists of Selected Plant Families (WCSP):

http://apps.kew.org/wcsp/home.do

WCSP contains updated checklists of 173 plant families in different stages of completion. Users can also develop their own checklists using a tool on the site. By selecting the family and genus under study as well as the continent and region of interest, the user may generate a summary or detailed checklist.

Lichenicolous fungi —worldwide checklist:

http://www.lichenicolous.net

A curated checklist of lichenicolous fungi, which are fungi that live exclusively on lichens as host-specific parasites, broad-spectrum pathogens, saprotrophs, or commensals (Lawrey and Diedrich, 2011). It is useful to lichen systematists, since lichen-fungus interactions are diagnostic for certain lichen lineages.

North American Lichen Checklist:

http://www.ndsu.edu/pubweb/~esslinge/chcklst/chcklst7.htm

A curated checklist for the lichen-forming, lichenicolous and allied fungi of continental United States and Canada with 5,355 species currently included (Esslinger, 2012). It is a cumulative project since the original version was first posted online in 1997 with 3,580 species, and it has been updated yearly by Dr. Theodore L. Esslinger at North Dakota State University.

"Where can I find high quality images of my taxa? Are there interactive learning tools available online to help reinforce difficult concepts and classroom material?"

2. Visual and Other Multimedia— Visual and multimedia resources are critical to systematics research by providing rich, descriptive information for the taxa of interest as well as their habitat. Visual and other multimedia resources include databases and interactive galleries with collections of images.

Arkive - Images of Life on Earth:

http://www.arkive.org/

Arkive is a project to centralize a digital image library from organisms across different domains of life, but with an emphasis on creating an image library of endangered species before they become extinct. It has high-quality videos and photographs of algae, plants, fungi (including lichens), and animals in nature and/or as voucher specimens.

Flickr:

http://www.flickr.com/

Flickr is a website (from Yahoo) used to share and manage pictures. It provides a search tool that improves its basic features. Flickr may not always provide scientifically accurate identification for images; however, Flickr does support image sets that are managed through other web resources listed in this guide, such as the Biodiversity Heritage Library and the Encyclopedia of Life. The Flickr format allows commenting on images, which may help researchers to identify unknown specimens.

Inside Wood:

http://insidewood.lib.ncsu.edu/welcome

Inside wood is a project to promote knowledge in wood anatomy. This site is useful for both research and teaching applications, with a search tool and large image database. The website provides an interactive key with over 200 features of wood anatomy that can help one to identify the material under examination.

Karlostachys Plant image gallery:

http://gardenbreizh.org/photos/karlostachys/album-9314.html

This photo album contains more than 50,000 plant images, organized by family and lower taxonomic ranks. Photos have been collected from around the web; users should take care to properly credit the original photographer and verify determinations.

Lichens Home Page—Sharnoff Photos:

http://www.sharnoffphotos.com/lichens/lichens_home_index.html

This website offers a photo collection to help users identify more than 1,200 lichens of North America. The website is linked to the most up-to-date North American Lichen Checklist and it was developed by two lichen photographers and several lichenologists. The photographs were taken in the development of the book Lichens of North America (Brodo, Sharnoff, and Sharnoff, 2001).

Morphbank:

http://www.morphbank.net/

Morphbank is a free database containing hundreds of thousands of specimen-based biological images. It allows researchers to deposit taxon images in private or private workspaces and to query other images deposited in the database.

Mushroom Observer:

http://mushroomobserver.org/

Mushroom Observer is a portal dedicated to fungi pictures. It helps people to identify different types of fungi, including lichens, in addition to offering networking opportunities. Users can upload pictures and the community may help identify species based on images. This helps establish a dialog among amateurs and professionals. It also has a search tool to easily find a specific taxon.

Paldat:

http://www.Paldat.org

Paldat is a palynological database of images and other pollen data for plant research. Paldat is maintained by the Society for the Promotion of Palynological Research in Austria.

Pictures of tropical lichens:

http://www.tropicallichens.net/

The largest collection of pictures of tropical lichens online, including a searchable list of thousands of species with photo credits and locality data. Photos are organized by genus and species. It is maintained by several lichenologists around the world and is linked to Index Fungorum and GBIF (both databases are listed below).

Smithsonian Institution Plant Image Collection:

http://botany.si.edu/PlantImages/

A searchable collection of more than 49,000 plant images, including species and their habitats. All images are freely available for non-commercial use, if properly credited.

Texas A&M University Vascular Plant Image Library:

http://repository.tamu.edu/handle/1969.1/97046

A gallery of vascular plant images organized by taxa. The gallery is organized alphabetically, first by family and then by genus.

Ways of Enlichenment:

http://www.waysofenlichenment.net/lichens/gallery.html

This site provides a regularly updated database of lichen images, which is searchable by several criteria.

"Where can I find relevant information about the taxa I am working on?"

3. General Plant and Lichen Biodiversity—In this section, we aim to help people identify information about taxa of interest. Most of these resources include websites that contain digital books, voucher specimens belonging to important collections, links to other sites, and repositories of images, but they may also include phylogenies and identification keys.

3a. Biodiversity reference—Angiosperm Phylogeny

Website: http://www.mobot.org/MOBOT/Research/APweb/welcome.html

A searchable website and tool for up-to-date information on angiosperm phylogenetics, hosted through the Missouri Botanical Garden. This site is organized according to ordinal classification and taxa are searchable on a scrolling left-hand panel. The angiosperm phylogeny website also includes distribution maps, a regularly updated bibliography, and glossary in addition to the detailed information on taxa.

Biodiversity Heritage Library:

http://www.biodiversitylibrary.org

BHL is a consortium of natural history libraries with the goal of providing thousands of historical biological documents online. A digitized bibliography helps users find old and new literature, which may be otherwise hard to find. One can browse by author, year, subject, titles, and languages, among other search criteria (e.g., search by species name).

Cyberliber: an Electronic Library for Mycology:

http://www.cybertruffle.org.uk/cyberliber/index.htm

Cyberliber is a digital library dedicated primarily to fungi (including lichen literature). There are several books, journals, and catalogues available online as well as a search tool to find literature about the study taxa.

Encyclopedia of Life (EoL):

http://eol.org

The Encyclopedia of Life is a publicly accessible database of natural history information that was initiated in 2007 with the goal of developing "a webpage for every species". With several collaborating institutions, EoL actively pursues this goal with a priority list for certain taxa. The Encyclopedia of Life continues to be updated and is a growing resource for researchers, as well as those with a passing interest in biodiversity. The EoL contains nomenclatural, phylogenetic, and visual and multimedia content for taxa. Much of the content is collected from other web-based biodiversity resources, such as GBIF, LifeDesks, Tropicos, etc.

General MOBOT Resources:

http://www.mobot.org/mobot/research/alldb.shtml

Missouri Botanical Garden's website lists numerous general botanical resources. It hosts several links to regional floras (linked to tropicos.org), and additional databases with valuable information about plants.

Global Biodiversity Information Facility (GBIF):

http://www.gbif.org

GBIF is a freely accessible resource for biodiversity information, including taxa, distribution, and digitization services. Much of the data available on GBIF is shared with and retrieved from other web-based biodiversity resources, including the databases of natural history collections. GBIF currently includes over 400 million records and continues to grow. GBIF communicates with many other biodiversity-related web resources, making it one of the largest biodiversity data tools available online.

Global Plants Initiative (GPI):

http://gpi.myspecies.info/

The Global Plants Initiative (GPI) is an international collaboration with the goal of digitizing and making available plant type specimens, as well as other resources to be used in education. The output of GPI is presented through JSTOR Plant Science.

Google Books

http://books.google.com/

Google books is another service for searching freely available online literature.

JSTOR Plant Science:

http://plants.jstor.org

This site is a digital archive and repository of plant science resources, specializing in historical collections. It contains numerous images and type collections, as well as digitized floras. Priorities of this initiative currently include digitizing type specimens; 2.2 million specimens are expected to be digitized by 2013. Other resources, such as regional floras, are also available.

Kew Science and Research Resources:

http://www.kew.org/science-research-data/index.htm

The website of the Royal Botanical Gardens, Kew describes their extensive research programs and distributes photographs, videos, collections data, and more.

Lucid Key Database:

http://www.lucidcentral.com/en-us/keys173;/searchforakey.aspx

This online tool allows users to search for interactive keys based on several criteria, including taxon, geographic range, and ecological features.

Missouri Botanical Garden Research Links:

http://www.mobot.org/MOBOT/Research/links.shtml

The pages associated with this site contain many hyperlinks to resources relevant to systematics researchers, under categories such as phylogeny, botany, societies and organizations, and tropical biology.

Recent Literature on Lichens:

http://nhm2.uio.no/botanisk/lav/RLL/RLL.HTM

This website is updated often; therefore, it is a valuable tool for finding current publications pertaining to lichens.

Tree of Life:

http://tolweb.org/tree/

The Tree of Life Web Project (ToL) is a collaborative effort of researchers to provide information about the biodiversity. Contributors must apply for authorship on taxon pages and supply a description of the morphology and evolutionary history (phylogeny) for each taxon.

Tropicos:

http://www.tropicos.org

Tropicos is a database and information network maintained by the Missouri Botanical Garden. Tropicos contains specimen, nomenclature, distribution, and other reference data for plant specimens from around the world, specimen data are mostly gathered from their holdings.

3b. Biodiversity tools—

Discover Life:

http://www.discoverlife.org

Discover Life is an initiative for educators and researchers that provides interactive tools for learning about biodiversity. Classroom activities and more complex student research projects are presented on the site. It includes online tools for developing labels, field guides, and maps as well as storage for images of taxa and locality information. Locality data for accessions can be uploaded and linked to a particular accession to generate maps and labels quickly.

Internet Directory for Botany (IDB):

http://www.botany.net/IDB/botany.html

The IDB is an extensive catalog of botany-related websites, organized alphabetically. Numerous gardens, guides, checklists, organizations, and other databases and references are included; the list is searchable.

iPlant Collaborative:

http://www.iplantcollaborative.org/

The iPlant Collaborative has developed a suite of cyberinfrastructure tools for plant biologists. The site promotes collaboration, learning, and research in plant science. Educational and research resources developed by the iPlant team cover evolutionary development, genomics, and phylogenetics. Researchers can use information resources such as cloud computing and storage on the iPlant Atmosphere service. iPlant also offers community-networking tools.

Symbiota:

http://symbiota.org

Symbiota provides software tools for sharing biodiversity data. Symbiota packages facilitate the development of electronic floras and faunas, keys, and other resources for improved collaboration on biodiversity research projects.

"How do I correctly use taxon names and know which one is valid?"

4. Nomenclatural Resources—Nomenclature is the practice of establishing the correct name for a taxon and is a key component of systematic research. Knowing a little bit of Latin can help, but understanding the International Code of Nomenclature (ICN) and using the correct taxonomic reference databases is essential. It is important to note here that taxonomy and its attendant nomenclature do change over time, for reasons that may be subjective (e.g., opinion of the researcher) or objective (e.g., changes in ICN rules). Consequently many databases do not reflect the current consensus regarding the accepted name of a given taxon but may list bibliographic information about possible synonyms. Moreover, nomenclatural databases may have errors in them. You should always verify names with reference to the most recent taxonomic literature in addition to scrutinizing the original publication documents. As always, it is good practice to contact the online nomenclatural database administrators with corrections if errors are found.

AlgaeBase:

http://www.algaebase.org

This database includes nomenclatural resources in algae, including taxa that are part of the lichen symbiosis.

Global Names Initiative (GNI):

http://www.globalnames.org

This website helps you to find information about biological groups across all domains of life through a search system that leads the user to other web resources. Under the find names service, the system detects scientific names in documents, URLs, or any type of free text. This service is very useful for finding names in encrypted or image-based PDFs.

Index Fungorum and Species Fungorum:

http://www.indexfungorum.org/

http://www.speciesfungorum.org/

Index Fungorum and Species Fungorum are nomenclatural databases for fungi (including lichens) with over 380,000 names.

Integrated Taxonomic Information System (ITIS):

http://www.itis.gov/index.html

ITIS is a federally funded taxonomic data clearinghouse for organisms, predominantly those found in North America, and aims to provide up-to-date authoritative information. Data are collated from US, Canadian, and Mexican partner agencies and are provided to larger global clearinghouses, such as GBIF. It also provides the user with a list of experts for given taxa and links to where one can find information about individual species.

International Code of Nomenclature for algae, fungi, and plants online (ICN):

http://www.iapt-taxon.org/nomen/main.php

The ICN establishes rules for nomenclature and is the most authoritative resource for understanding the nomenclatural system for plants and lichens.

International Plant Names Index (IPNI):

http://www.ipni.org

The International Plant Names Index (IPNI) is a searchable database containing information on plant nomenclature, authorities, and author publications. IPNI is an excellent resource for looking up plant names and authors. Nomenclatural data come from the *Index Kewensis* database, supported by the Kew Botanical Gardens.

MycoBank:

http://www.mycobank.org/

MycoBank is a database created with the purpose of serving the scientific community through documentation of new mycological nomenclature (names and combinations, including lichen) and other data, such as descriptions and illustrations.

PhyloCode:

http://www.ohio.edu/phylocode/

The PhyloCode is a formal set of rules governing phylogenetic nomenclature. It is designed to name the parts of the tree of life by explicit reference to phylogeny. The draft is available online and is open for suggestions and comments.

The Plant List:

http://www.theplantlist.org/

This site contains a working list of all known plant species. It provides an accepted name for most species along with links to all synonyms.

Plantminer:

http://www.plantminer.com/

This web-based application searches for names and synonyms of plant species. Users can submit a taxonomic query and a list will be returned via email from the Tropicos and Plant List databases.

Universal Biological Indexer and Organizer (Ubio):

http://www.ubio.org

Ubio is designed to integrate biological name data *and* classification data. The Name Server tool is described as a biological "name thesaurus". It also contains introductory information on classification and species concepts.

"Where can I find scientific vouchers for study? How do I handle specimens appropriately?"

***5. Collections and Collections Management*—** Herbaria are located all over the world and are rich sources of material for plant and lichenological systematics research. Contacting these institutions and examining loans of specimens is a component of many systematics research projects. These specimens, all of which are irreplaceable and unique samples of the natural world, require archival storage conditions and careful handling procedures, and all beginning researchers should be aware of these practices. The following are links to a searchable index of international herbaria, as well as links to organizations that serve herbarium curators and provide best practices for collections-based research, including preparation of specimens for both physical and digital preservation.

Registry of Biological Repositories:

http://www.biorepositories.org/

Biorepositories is a database of natural history collections accession information. Biorepositories works with numerous institutions and will also be linking with other large collections databases in the near future, including Index Herbariorum (below).

Consortium of North American Bryophyte Herbaria (CNABH):

http://bryophyteportal.org/portal/index.php

CNABH is a distributed network dedicated to integrating herbaria that carry bryophytes. It offers tools to locate voucher specimens as well as their images, plus checklists curated by experts in the subject.

Consortium of North American Lichen Herbaria (CNALH):

http://lichenportal.org/portal/index.php

CNALH is similarly to CNABH but integrates lichen research tools. Both were initially created by the American Bryological and Lichenological Society, but currently are maintained by separate entities.

Index Herbariorum (IH):

http://sciweb.nybg.org/science2/IndexHerbariorum.asp

Index Herbariorum is a searchable database of all herbaria in the world. IH merged with biorepositories.org in 2012 and can also be accessed through their website.

Integrated Digitized Biocollections (iDigBio):

https://www.idigbio.org/

iDigBio is an online resource for promoting the digitization of biological collections. This site facilitates digitization and makes digitized specimens available to the public.

International Society for Biocuration (ISB):

http://www.biocurator.org

Like SPNHC (below), ISB is a leading international organization for biocuration and provides support of and advocacy for biocuration.

Kew Herbarium Catalogue:

http://apps.kew.org/herbcat/navigator.do

Similar to Index Herbariorum (above), the KHC provides a searchable listing of international herbaria.

Society for the Preservation of Natural History Collections (SPNHC):

http://www.spnhc.org/

SPNHC is an international organization that promotes the curation, preservation, and innovation of natural history collections and provides resources for researchers interested in such collections.

"I need to collect specimens, how do I do this legally?"

6. Fieldwork and Permitting—As a graduate student, you might need to collect your own material, which means you may need a permit to do so legally. We acknowledge that different parks, states, and countries have different permitting processes; therefore, we encourage the user of this guide to look for specific laws that apply to the relevant jurisdiction. We have some suggestions to help start the process. Outside the US, the best recommendation is to contact a colleague at a local accredited institution rather than trying to start the permit process on your own.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):

http://www.cites.org/

CITES is an international organization that governs the import and export of endangered species across international borders. CITES also helps facilitate communication of researchers who may be importing or exporting listed species which require a CITES permit. National agencies charged with permitting can be found at http://www.cites.org/cms/index.php/lang-en/component/cp/.

Lichen collection and identification at the Farlow Herbarium, Harvard University:

http://www.huh.harvard.edu/collections/lichens/index.html

This website hosts guides to several subjects in general and North American lichenology. It provides a vast list of literature about different topics when working with lichens in the US, but also gives tips on important characters of different morphotypes in lichens. Under the "How to collect lichens?" link, the site offers detailed advice on how to collect lichens appropriately based on text developed by Philip F. May. The information available in the website contributes good quality material and analysis in depth.

Missouri Botanical Garden Field Techniques:

http://www.mobot.org/MOBOT/molib/fieldtechbook/welcome.shtml

This website describes standard techniques used by MOBOT botanists in the field. Techniques are categorized and can be browsed with detailed descriptions for each.

United States Fish and Wildlife Service (FWS):

http://www.fws.gov/ and http://www.fws.gov/permits/

The USFWS provides permits for research activities in localities under USFWS jurisdiction. If you are uncertain whether your research requires permits, visit the link above or contact a FWS representative.

United States National Park Service (NPS):

https://science.nature.nps.gov/research/ac/ResearchIndex

The USNPS grants permits for collecting wildlife materials from locations within the US National Park system.

"Where can I find information about protocols for a new or unfamiliar laboratory technique? Are there tools available online to help me troubleshoot my methods and protocols?"

7. Laboratory Protocols—Developing new lab protocols or troubleshooting existing protocols can often take more time than first expected. Searching for the right reference can be difficult; however, there are some helpful resources available to resolve your problems. Two texts highly recommended for laboratory basics and troubleshooting are Barker (2005) and Hillis, Moritz, and Mable (1996).

Lab Protocol:

http://www.labprotocol.com/index.php

Lab Protocol provides information for researchers to look up protocols available from different institutions and to store their own methodologies for easy access. This resource has protocols in several areas of biology.

Promega, Inc.:

http://www.promega.com/resources/

Promega is a well-known distributor of molecular laboratory products and services. Although most support offered online through Promega is specific to products they offer, they also offer many protocols, tools, and other resources free of charge.

Protocol Online—Your lab's reference book:

http://www.protocol-online.org/

Protocol online offers a variety of protocols related to biology in several subcategories. It also provides creative ideas for activities for teaching biology.

"I need intensive or specialized training not available at my university" "Where can I find lectures and other learning material online?"

8. Courses, Workshops, and Guides—Courses and workshops are an important part of graduate student training, but sometimes your university doesn't offer everything you need. In this section, we include a list of courses in systematics-related fields that are offered annually by institutions with open registration to graduate students and professionals. We also present a short list of guides for different programming and scripting languages. Each guide is written with a specific emphasis on biological applications or programming languages that are often used by those in biological disciplines.

8a. Computing languages for research—

Codecademy:

http://www.codecademy.com/

Codecademy is a free training service available to anyone that offers computer code teaching exercises for basic and advanced programming applications. Guided teaching modules allow users to familiarize themselves with basic scripting tools for writing their own applications and developing websites.

iTunes Podcasts on iTunes U:

http://www.apple.com/education/itunes-u/

iTunes U provides lecture and classroom content for download. Material available through iTunes U is available through any device that can run iTunes software. Lectures can be recorded, uploaded, and stored on iTunes and made available to students or the general public. Photos and other multimedia documents can be stored along with individualized notes that can be synchronized with the lecture. This is a free resource, and several universities and colleges are already making lectures publicly available through this venue.

Udacity:

http://www.udacity.com/

Udacity provides free teaching modules for the public in basic and advanced computer programming applications. Udacity's teaching modules are guided and application-based. All lessons can be completed within the web browser of choice.

8b. In-person resources—

Bodega Phylogenetics:

http://bodegaphylo.wikispot.org/

Bodega Phylogenetics hosts an annual Applied Phylogenetics Workshop each summer at the Bodega Marine Lab in Northern California. The Bodega Phylogenetics team also maintains and actively updates their Wiki page, where visitors can download tutorials and participate in discussions.

Evolution and Genomics (Evomics):

http://evomics.org/

Evomics offers workshops and training in molecular evolutionary biology and genomics. Tutorials and other resources are available through their website and several workshops are hosted internationally throughout the year.

Molecular Evolution:

http://www.molecularevolution.org/

This organization offers US and European workshops and as well as online training modules for topics in molecular evolution, comparative genomics and phylogenetics.

National Evolutionary Synthesis Center (NESCent):

https://academy.nescent.org/wiki/Main_Page

NESCent is a non-profit organization that supports interdisciplinary research in evolutionary biology. The organization sponsors annual training courses and small group workshops and offers fellowships for students.

Organization for Tropical Studies (OTS):

http://www.ots.ac.cr/

OTS is a non-profit organization created in a partnership between universities from the US, Australia, and Latin American countries to promote training in tropical field biology. It offers field courses in Costa Rica year-round to undergraduate and graduate students on topics ranging from tropical plant systematics to conservation biology.

Eagle Hill Institute and Foundation:

http://www.eaglehill.us/programs/nhs/nhs-calendar.shtml

This institute and foundation is a nonprofit organization dedicated to education, especially in the natural history sciences. It offers field courses on lichens and plants, among other organisms, every year between May and September on its campus in Maine, the site of the former Humboldt Field Research Institute.

"How will I fund my research?"

9. Funding—Securing funds for research is a requirement for anyone who wishes to pursue research professionally, and graduate school is an excellent place to begin grant writing. Often, professional societies (see later category) offer small research and travel grants to graduate students specifically. Private businesses as well as non-profit organizations such as philanthropic foundations as well as local and federal government agencies sponsor larger awards, which may include grants for research or more inclusive research fellowships. Below are links to groups besides professional societies that provide funding opportunities for graduate research in the sciences.

American Philosophical Society (APS):

http://www.amphilsoc.org/grants

APS has provided grants in support of basic research since 1933. There are several grant and fellowships opportunities available to students and early career scientists.

Fulbright:

http://us.fulbrightonline.org/

The Fulbright student program has been active since 1946 and provides competitive research awards to students internationally, although this link is for students who are US citizens. Research awards include funding for residency in the country of study.

Garden Club of America (GCA):

http://www2.gcamerica.org/outreach-scholarships.cfm

The GCA offers grant-based awards for several categories of plant-related research.

National Geographic:

http://www.nationalgeographic.com/explorers/grants-programs/

National Geographic has annual openings for grants in many subjects relevant to systematists, including a program for scientists under the age of 25. Their site has a search tool under the section "grants A-Z," which can help narrow down the options.

National Science Foundation (NSF):

http://www.nsf.gov/funding/

Opportunities for students include graduate research fellowships and doctoral dissertation improvement grants (DDIG). NSF also provides links to other funding sources for scientific research in broad categories.

"Is there a software program that can do X, Y, or Z with my data already? Or do I have to write it myself?"
"I have a lot of intensive computational analyses to do, but not enough machines or time..."

10. Computing—Computing resources for systematics research have been categorized here as cloud computing resources and software resources. Cloud computing may occur on one or many remote processors; it is also termed *distributed computing*. We suggest that users new to cloud computing always prepare a short input file as a test to make sure that data can be uploaded to, analyzed by, and retrieved from the cloud-based software service successfully. Conducting similar tests using local installations of the distributed software can also help new users use cloud resources most effectively. We also recommend that users explore a scripting language to familiarize themselves with common notation and file formats. A thorough introduction to computing for phylogenetic biologists is described in Haddock and Dunn (2011).

10a. Cloud computing—Cloud computing allows users to both store data and conduct computational tasks remotely. Remote storage and computing can be valuable for backing up data and also accomplishing tasks that often exceed the processing power or time available to researchers at their home institution. Many cloud resources are available for modest fees or are free.

Amazon Web Services:

http://www.aws.amazon.com

AWS offers for-cost storage and distributed computing services for a variety of tasks. Many users have developed computing pipelines for analyzing genomic datasets through AWS.

Cyber Infrastructure for Phylogenetic Research (CIPRes):

http://www.phylo.org/index.php/portal/

CIPRes Science Gateway is a user-friendly portal for performing computationally intensive phylogenetic analyses. It is a free service, but the user needs to create an account. An individual account is allowed to consume up to 30,000 CPU hours of computing time, or 50,000 for users affiliated with US institutions. Once a data file has been uploaded, that file can be analyzed using any of the tools available on CIPRes. CIPRes also provides detailed instructions for file formatting and file testing.

University of Oslo Bioportal:

http://www.bioportal.uio.no/

The Bioportal is another free and user-friendly portal for conducting phylogenetic analyses but supports a wider range of software programs, including those specifically for population genetics analyses. It hosts more than 40 programs and allows users to download these programs to their local computers as well.

10b. Software and Tools—There are numerous phylogenetic software programs available for download, some of which are free and open-source and others that are proprietary and/or must be purchased. An important point to remember is that not all programs are subject to rigorous beta testing and that their performance cannot be guaranteed. Popular programs typically have community-based message boards, such as wikis, that may list important bugs or other limitations not otherwise described in the user-manual. Many of the programs do not have a GUI component and must be run from the command line, thus one of the first steps to using them is to become familiar with this type of operating environment. We also suggest using a stand-alone text-editing program, such as TextWrangler, in which to create and modify command files. Hall (2011) and Lemey, Salemi, and Vandamme (2009) also present guidance on creating phylogenetic trees through some practical software exercises and explain the theory behind the methods used.

Alignment Transformation EnviRonment (ALTER):

http://sing.ei.uvigo.es/ALTER/

ALTER is a tool that interconverts file formats. Different software programs often use separate file formats (e.g., .nex vs. .phy), and you will inevitably need to perform file conversions between them.

BioPerl:

http://www.bioperl.org/wiki/Main_Page

The wiki available through BioPerl offers resources for training biologists in the use of Perl scripts for data analysis. Script templates for common tasks are available for download and the community at BioPerl is able to answer questions for users who encounter problems with datasets or Perl scripts.

Biopython Tutorial and Cookbook:

http://biopython.org/DIST/docs/tutorial/Tutorial.html

This online tutorial of Python is relevant for computation of biological datasets. A library of Python scripts for phylogenetic analyses (DendroPy) is available through http://packages.python.org/DendroPy/.

BLAST: Basic Local Alignment Search Tool (BLAST):

http://blast.ncbi.nlm.nih.gov/Blast.cgi

BLAST finds regions of similarity between DNA or protein sequences. It compares user-uploaded sequences and/or sequences already in the NCBI database (see above) and provides information about the potential identity of query sequence data based on matches in the system.

The Felsenstein Phylogeny Program Pages at the University of Washington:

http://evolution.genetics.washington.edu/phylip/software.html

This is a curated and frequently updated descriptive list of software programs for systematics research, with an emphasis on phylogenetic and population genetic analysis software packages. The user can search for software by name, method, computer system, etc.

R:

http://www.r-project.org/

R is a computing language with broad applications for statistical research. We recommend the APE package in R, which supports comparative phylogenetic functions.

Text Wrangler:

http://www.barebones.com/products/TextWrangler/

Text Wrangler is a dedicated text editing program appropriate for manipulating datasets and command files. It offers greater editing capabilities than standard word-processing programs (e.g., MS Word). For example, it has more "search and replace" options and interconverts UNIX, PC, and Macintosh line-break formats. It is free, but only available for Macintosh OS. We recommend

Notepad++ (http://notepad-plus-plus.org/) as an alternative to Text Wrangler on the P.C.

TreeTapper:

http://www.treetapper.org

This site is similar to the Felsenstein Phylogeny Program site (above) in that it is curated by a single individual. However, it includes a more detailed search engine and discussion of analytical problems that may not yet be addressed by available programs.

Wikipedia: List of phylogenetics software

http://en.wikipedia.org/wiki/List_of_phylogenetics_software

This list is frequently updated by the broader phylogenetics community. For each program entry, there is a short description, a citation, and link to the web address for each program.

"Has someone else collected a dataset I could incorporate into my own research? Where can I archive and store my data, besides my lab notebooks, my hard drives, and my publications?"

11. Molecular and Phylogenetic Databases—Many open access databases exist for storing and sharing biological data, and archiving one's data in these locations is often a prerequisite for publication. In all cases listed here, accessing and downloading data are free.

Barcode of Life Database (BOLD):

http://www.barcodinglife.org

BOLD is a resource meant to promote and support the development of DNA barcodes for living organisms. BOLD serves as an international repository of DNA barcode data and a resource for information on barcodes.

Dryad:

http://datadryad.org/

This is a data repository governed by a consortium of peer-reviewed journals. Since most journals have limited printed space, Dryad offers an opportunity to the authors to deposit additional information and make it available online for further investigation and discussion.

National Center for Biotechnology Information, including GenBank:

http://www.ncbi.nlm.nih.gov/

The Center, funded by the US federal government, maintains GenBank, which is the centralized database for biological sequence data, in addition to other molecular genetic databases. GenBank is part of a consortium of international sequence databases, including the DNA Databank of Japan (DDBJ) and European Molecular Biology Laboratory (EMBL), and cross-lists their entries as well. Currently there are more than 100 million sequence records in GenBank, each of which is publicly searchable. NCBI also maintains a number of online analysis tools, such as BLAST, that can facilitate systematics research.

TREEBASE:

http://treebase.org/treebase-web/home.html

TREEBASE allows researchers to submit and store "phylogenetic trees and the data used to generate them" used in support of published research.

"Where can I find maps to use in presentations, publications, and analyses? GIS software is expensive and challenging to use, so are there any tools that make this easier?"

12. Geographic Information Systems (GIS) and Maps—Visualizing and analyzing distributional data of taxa are often critical components of systematics research projects. Below are links to map resources and other data, as well as software for geographic analysis of biological data.

12a. GIS Data—

CCAFS GCM Data Portal:

http://www.ccafs-climate.org/

The CCAFS GCM Data Portal provides global climate modeling GIS data for use in GIS applications. These data are freely available for non-commercial uses.

Federal Geographic Data Committee (FGDC):

http://www.fgdc.gov/

FGDC is a multi-agency host of geographic data, which provides maps and other resources as well as grants and training opportunities for researchers. FGDC is hosted by the USGS.

Natural Earth:

http://www.naturalearthdata.com/

Natural Earth is a host of open access, public domain map, and GIS data. These high-quality resources are freely accessible. There is also a discussion forum for users.

WorldClim Global Climate Data:

http://www.worldclim.org/

WorldClim is a freely accessible data repository for GIS climate and ecological data.

12b. GIS tools—

DIVA GIS:

http://www.diva-gis.org/

DIVA-GIS is a free GIS software package designed specifically for use with biological data.

Earth Explorer:

http://earthexplorer.usgs.gov/

Earth Explorer is a tool maintained by the US Geological Survey (USGS) that hosts searchable map and GIS data.

ESRI, Inc.:

www.esri.com/

ESRI, Inc. produces ArcGIS, which is an industry-standard geographical information software package. ESRI also provides GIS information and resources for users and hosts data, some of which are available for free through their website.

MapWindow GIS:

http://www.mapwindow.org/

MapWindow is a free GIS package for visualizing and manipulating geographic data.

National Geographic Map Maker Interactive (MMI):

http://education.nationalgeographic.com/education/mapping/interactive-map/?ar_a=1

As the name implies, MMI is an interactive, web-based map-making tool that uses a user-friendly Flash interface to explore maps of interest. Map images can be manipulated using the interactive web tool and downloaded to your computer.

"Are there organizations I can join that support my research, or offer assistance through networking and collaboration, funding, or other resources?"

13. Professional Societies—Below are several professional societies, besides the Botanical Society of America (http://www.botany.org), that are relevant to plant and lichen systematics researchers. Some publish journals, offer discounted student membership rates, and sponsor student research grants. Professional societies can be an excellent way to meet potential collaborators and network with other researchers in your field of interest. Due to the sheer number of international professional societies, we have opted to only include societies that are based in the North America; however, we have also included a few organizations that have an international scope but are based outside of North America.

American Bryological and Lichenological Society (ABLS):

http://www.abls.org/

American Fern Society (AFS):

http://amerfernsoc.org/

American Society of Naturalists (ASN):

http://www.asnamnat.org/

American Society of Plant Biologists (ASPB):

http://my.aspb.org/

American Society of Plant Taxonomists (ASPT):

http://www.aspt.net/

Canadian Botanical Association/ L'Association Botanique du Canada (CBA/ABC):

http://www.cba-abc.ca/cbahome.htm

International Association for Lichenology (IAL):

http://www.lichenology.org/

International Association of Plant Taxonomists (IAPT):

http://www.iapt-taxon.org/index_layer.php

Phycological Society of America:

http://www.psaalgae.org

The Mycological Society of America (MSA):

http://www.msafungi.org/

Society for Systematic Biology (SSB):

http://www.systbiol.org

Society for the Study of Evolution (SSE):

http://www.evolutionsociety.org/

How can I find potential collaborators online or join a community of like-minded researchers?

14. Social Networking—Electronic social networking applications are becoming more widely used by researchers to share ideas and collaborate on projects. News and events can be disseminated, discussed, and tracked for a variety of purposes; we encourage readers to investigate the networking potential that these resources offer.

Academia.edu:

http://academia.edu/

This site caters to students and researchers in academia, providing opportunities to "follow" the research of colleagues or other researchers whose work one might have an interest in. It allows users to post manuscripts and can link users based on their discipline and academic interests.

Facebook:

http://www.facebook.com

Professional organizations, researchers, and funding institutions are networking and updating news and providing research announcements with tools available through traditional social networking sites, such as Facebook.

Figshare:

http://figshare.com/

This website allows users to make an account where they can store and share data in a searchable format. All data uploaded to FigShare is protected by a Creative commons license and, Figshare offers up to 1GB of storage for free.

Google Plus:

https://plus.google.com/

Google+ is a social networking site like Facebook that allows for networking and following groups, which Google calls "circles".

LinkedIn:

http://www.linkedin.com/

LinkedIn is another social networking tool, which specifically focuses on networking for business and academic professionals.

My-Plant:

https://my-plant.org/

My-Plant is a social network hosted through the iPlant Collaborative (listed above). My-Plant organizes participants by their taxonomic specialty using a tree-based phylogenetic approach. Researchers and collaborators can "join" a particular clade of interest and discuss research, news, and interact through the services available at My-Plant.org.

Pinterest:

http://pinterest.com/

The site is a content sharing service that allows members to "pin" images, videos and other objects to their user page.

ResearchGate:

http://www.researchgate.net/

ResearchGate is a social networking website dedicated to professional scientists. The goal of Research Gate is to improve networking and collaboration among researchers.

Twitter:

https://twitter.com/

Similar to the networking possibilities available through Facebook, Twitter has also become a useful tool for interacting with potential collaborators, as well as following news and information from institutions, researchers, and professional societies.

"What am I going to do after graduation? How can I get the job I want?"

15. Employment and Career Development— In this section, we focus on resources available to help guide students through graduate school to their future career. Three texts (Feibelman, 2011; Peters, 1997; and Vick and Furlong, 2008) are recommended, which contain helpful tips for meeting and understanding career and professional development goals.

The American Society of Plant Taxonomists job listings:

http://www.aspt.net/publications/newsletter/jobs.php

Similar to the BSA jobs website (below), the ASPT regularly updates position announcements for plant taxonomy-related careers.

Association for Women in Science (AWIS):

www.awis.org

This association provides career resources, advocacy, and professional development opportunities to women in science.

The Botanical Society of America job listings:

http://jobs.botany.org/

The BSA website maintains an up-to-date listing of jobs available for post-doctoral research, fellowships, and botany-related careers.

The Chronicle of Higher Education:

http://www.chronicle.com

This journal is a leading publication about news and issues in academic research, teaching, and administration. It also maintains an extensive section on academic careers and academic job postings.

EvolDir:

http://evol.mcmaster.ca/evoldir.html

EvolDir is a regularly updated news and bulletin website for evolutionary biology. The website maintained postings for jobs, which include positions in academia, graduate student positions, and post docs.

Science Careers:

http://sciencecareers.sciencemag.org/

This site, hosted by Science Magazine, contains a wealth of career resources, articles, and job postings.

The Society for American Chicanos and Native American Scientists (SACNAS):

www.sacnas.org

This society provides career resources, advocacy and professional development opportunities to American Chicanos and Native Americans in science.

DISCUSSION

This guide is not intended to promote or advocate the use of any particular text, tool, protocol, or database over another, but rather to serve as a clearinghouse for and introduction to the wide variety of tools available to graduate students and early career researchers beginning their studies in plant or lichen systematics. Further, the authors hope that this guide might encourage researchers in other related fields to develop their own cyberinfrastructure navigation guides for students and others entering or exploring new frontiers. We welcome additions to this online version of this guide: http://www.botany.org/students_corner/systematics_resources.php.

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Book Reviews

Bryological

Common Mosses of the Northeast and Appalachians

Karl B. . McKnight, Karl B., Joseph R. Rohrer, Kirsten McKnight Ward, and & Warren J. Perdrizet
2013. ISBN-13: 978-0-691-15696-5
(Paperback, US$24.95.) 392 pp.
Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237USA.

I can't tell you how many times I have been asked by amateur naturalists in New England to recommend a good field guide to the mosses. I usually suggest several books from other regions (Michigan, Pennsylvania, or the southern Appalachian Mountains) that cover broadly distributed genera, have color photos, and do not require a microscope for identification (Glime, 1993; Munch, 2006; Davison, 2007). For New England naturalists, these guides suffice for generic-level identifications, but the need for a regionally appropriate guide has persisted for far too long. *Common Mosses of the Northeast and Appalachians* fills this long-standing gap, covering mosses of the northeastern United States and Canada from Nova Scotia to Wisconsin and south throughout the Appalachian Mountains.

The book's introduction is thorough yet concise. Readers are taught how to use a hand lens, oriented to basic moss structures, and introduced to the moss life cycle. The authors take the time to review what I like to call "mossy misnomers"; plants whose common names include the word "moss," but are not in fact bryophytes. This section also covers how to discern mosses from other small, potentially confounding plant relatives. Instructions are given for making a collection voucher, including details on how to fold collection packets and which information should accompany the specimens. The introduction concludes with the authors answering the burning question "What good are mosses?" by touching on a bevy of topics including the connections between mosses and ecosystem services as well as their usefulness to humans. The authors take a moment to provide a brief word of caution to remind the reader to refrain from collecting in prohibited areas, such as national or state parks. If there were anything I would add to this informative introduction it would be a brief discussion of moss conservation in order to stimulate the reader to think about the sustainability of harvesting economically useful mosses and the impact of habitat destruction on these and other plants.

Common Mosses is a field-ready companion even in the physical sense. It is a nice compact size that easily fits in one hand and is covered by a clear, waterproof dust jacket. The first thing I noticed flipping through the book are the multiple colored tabs on the page edges. These tabs form the core of the identification key, which focuses on three main features of the leafy gametophyte: growth form, leaf shape, and leaf midrib. The authors dedicate several pages to explaining these key features using both drawings and photos. Then the reader is directed to either the tabbed pages or the dichotomous keys, which are both organized into 12 groups of mosses with similar morphologies. By focusing first on these three main features, the individual dichotomous keys are not intimidating in length and the majority of species are identified in less than ten couplets. This will be a refreshing identification experience for anyone who has tried to identify plants in the field using a guide with an overwhelming number of couplets.

Both color photos and line drawings illustrate the 150 main species in the book. Line drawings, originally published in the classic two-volume tome *The Mosses of Eastern North America* (Crum and Anderson, 1981), focus on sporophyte capsules in addition to habit and leaf shape. These line drawings are accompanied by color photographs, which together comprise a full page of illustrations for each species. The color photos focus on gametophyte habit and leafy stems. Some mosses look quite different wet versus dry, a situation that is usually remedied by taking a bottle of water into the field for both personal and bryological hydration. The authors address this issue by including side-by-side photos of both conditions for a quarter of the species included in the guide. Photos for some species include the sporophytes, but they are never the focus. The sporophyte phase of the life cycle is the most seasonably variable, and thus I think it was a wise choice to center the images and identification on gametophyte features.

Each main species also has a full page of text detailing its appearance, leaves, capsules, and habitat(s). Broad-ranging mosses are the focus of this book, and rare or endemic species are lacking. Unfortunately, that means that species' distributions are not included in the text. Including a list of states or small map indicating the distribution for each moss would have been helpful for readers to confirm that a species is present in their area. The text is complemented by a short list of "similar species," and their distinguishing characteristics to help the reader discern them from the species in question. The brief treatment of "similar species" contributes information for an additional 46 taxa not covered elsewhere in the book, without adding multiple entries for similar taxa or lengthening the dichotomous keys. At the end of each species description, a few microscopic features are listed to entice readers to further explore the mosses beneath the microscope.

The four authors include two botany professors, a professional artist, and a former undergraduate biology student. This unique combination of expertise results in a particularly accessible text for both budding and seasoned naturalists, requiring only a hand lens and a desire to explore. I have no doubt that this guide will become a trusted field companion for outdoor educators and amateur naturalists, who may be new to moss identification, as well as to botanists interested in refreshing their moss identification skills. *Common Mosses* fills a long-standing void in moss field guides for the region, and, as such, this guide will make the identification of these small plants more accessible to a wider botanical audience.

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Developmental and Structural

The Anatomy of Palms: Arecaceae–Palmae

P. Barry Tomlinson, James W. Horn, Jack B. Fisher
2011. ISBN-13: 978-0-19-955892-6
Cloth, US$225.00, £135.00. 251 pp.
Oxford University Press, New York, New York, USA

The Arecaceae is a family of superlatives—sky-high plants with massive, tree-like trunks and enormous, spreading fronds—which divide up into five subfamilies and 183 genera. Palms are of extreme economic and cultural importance in the tropical realm, and are an icon of the tropics recognized by people in all climatic zones of the world. The latest treatise on these plants, *The Anatomy of Palms: Arecaceae–Palmae*, is also superlative—a monumental monograph that describes internal structure in this huge plant family in a phylogenetic context. Yet the book is a concise 251 pages containing 60 line drawings, cladograms, and tables, as well as 88 figures composed of some 800 individual images.

Leading palm botanists P. Barry Tomlinson, James W. Horn, and Jack B. Fisher were able to tap into the diversity of Arecaceae at the Fairchild Tropical Botanic Garden in Florida, but also drew on material from all over the globe to document their anatomical swath through this predominantly tropical and subtropical family. Altogether, all 183 species of Dransfield et al. (2005, 2008) were examined; however, only selected taxa were targeted for description and illustration in the book. Thus, the authors offer an apology for their "big picture approach," although, in my opinion, their misgivings are unwarranted. When 800 anatomical images are chosen out of some 2500 altogether, you can be sure that only the best and most exemplary were included. Indeed, most of the pictorial images are color photomicrographs of vividly stained anatomical sections, but there are also a few macrographic images depicting the overall aspect of the palms.

It should be noted that *The Anatomy of Palms* is "only" limited to the vegetative parts of the palms, which must have been a massive undertaking in itself. Reproductive parts, with the exception of a few photos of distinctive fruiting heads of the mangrove palm *Nypa*, are not covered in the volume.

The book opens with nine introductory chapters on the preparation of anatomical material, the general construction and classification of palms, and the evolution of structures. The second part of the book, which accounts for about two thirds of the volume, consists of detailed descriptions of this structurally complex family of plants and is organized by subfamily, tribe, and subtribe within a molecular systematic framework based on the system of Dransfield et al. (2005, 2008b).

The treatment of each subfamily begins with an introduction that includes its current biogeography, fossil history, and phylogenetic position. Afterwards, each part of the vegetative plant body is described, starting with the leaf and its lamina, petiole, and leaf sheath. The description moves on to the stem, root, vascular elements, and cell inclusions. When arranged in this standardized way, the reader is able to find information efficiently within each section. However, the anatomical description of each subfamily is more than a mere laundry list of facts, for each group is treated individually, with an emphasis on data and details pertaining to only that group. The writing in the non-anatomical sections is elegant and contains pertinent references, while that in the anatomical descriptions is succinct and straightforward.

Indeed, one thing that I really appreciate about *The Anatomy of Palms* is its good organization and the thoughtful application of typography. Varied, attractive type styles and sizes are consistently used to set off the different orders of headings and to emphasize partitions within blocks of text. With so many illustrations, the bookkeeping of species names in the figure captions and magnification size of the scale bars must have been a nightmare, yet all micrographs have a uniform scale bar placed neatly in the lower right at presumably the right size. I also like the aesthetically pleasing staining of anatomical sections, as well as the nod to the history of science in the form of lovely line drawings published by the first palm anatomist Hugo von Mohl in the mid-19th century. For those seeking specific information within the book, there are two indices, one to scientific names and a second to subjects in the book.

The Anatomy of Palms is a handsome book, with thick, glossy paper, excellent printing, and photos with good color, balance, and contrast. However, don't let the cheerful, palm green dustcover fool you, for this is a book for specialists, and not a general guide for the hobbyist palm-grower. Having said that, this publication is clearly a milestone in the study of the Arecaceae and a definite must for all science libraries, botanical institutions, palm systematists, and plant anatomists.

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–Carole T. Gee, Steinmann Institute, Division of Paleontology, University of Bonn, Bonn, Germany

Ecological

Air Plants: Epiphytes and Aerial Gardens

David H. Benzing
2012. ISBN-13: 978-08014-5043-3
Hardcover, US$39.95. 239 pp.
Comstock Publishing Associates, a division of Cornell University Press, Ithaca, New York, USA

David Benzing's exuberance is evident throughout this book. His love of epiphytes—their lifestyles, varied forms, growing places, and their relationships with the environment, to animals, and to humans—captivates the reader. Benzing discusses all aspects of epiphytism without excessive dependence on technical terminology and with an understanding of the intellectual scope of his readership. From the opening section, "What is an epiphyte?," to the final section on threats and conservation, he explains the epiphytic way of life.

The last treatment of epiphytes that accounted for the reaction of epiphytes to light, humidity, and temperature was probably that of plant geographer Andreas Franz Wilhelm Schimper more than 100 years ago. Benzing covers the entire spectrum of epiphytic life, including the evolutionary origin of epiphytes, communities of epiphytes, how these "air plants" receive nutrients and maintain water balance, how they reproduce sexually and asexually, and how they interact with animals, particularly those responsible for pollination. Many epiphytes provide shelter and food for a variety of animals, especially insects, salamanders, frogs, and sometimes even crustaceans! Bromeliads provide water tanks at the bases of their leaves that harbor diverse animal communities elaborated by Benzing, who hypothesizes the benefits to animals from their epiphytic hosts.

A large portion of Benzing's opus is devoted to describing the taxa of plants in which epiphytes predominate, as well as others where epiphytes are less dominant but still important. He discusses the physiological adaptations to epiphytism as well as the anatomical and morphological.

Major plant groups noted for epiphytism are Orchidaceae, Bromeliaceae, and Araceae among the monocots and Cactaceae, Ericaceae, and Gesneriaceae among the dicots. With the pteridophytes, ferns and lycophytes predominate. Carnivorous epiphytes, stranglers, and hemi-epiphytes are treated as well as a few gymnosperms (e.g., *Zamia pseudoparasitica* of Panama). For all of these taxa, Benzing analyzes their physiology and ecology; for the cacti and gesneriads, he explores their hypothesized evolutionary history.

A final chapter concerns threats to epiphyte habitats, attempts at conservation, the role of epiphytes in modifying or producing microclimates, and their contribution to biodiversity.

The appended glossary is of great help to the nonspecialist who might refer to this book, and the references to associated literature provide direction for those seeking further information or who seek to verify conclusions drawn in this work. The carefully constructed index helps readers to locate areas of interest.

The clear and precise line drawings result from the talented hand of the author, and the photographs have been brought together to illustrate certain features of the text. Many of the photos were taken by the author in the field.

Benzing's is a well-conceived and well-executed testimony to epiphytes and serves to bring together up-to-date information about these not very well understood plants. It provides a basis for further inquiry to round out our understanding of this peculiar life style of plants and points out areas where further study would be productive.

–William Stern, Botany Department, The Kampong, Miami, Florida, USA

Invasive Plant Ecology

Shibu Jose, Harminder Pal Singh, Daizy Rani Batish, and Ravinder Kumar Kohli (eds.) 2013. ISBN-13: 978-1-4398-8126-2 (Hardcover); ISBN-13: 978-1-4398-8127-9 (E-book) Hardcover and E-book, US$99.95. 302 pp. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA

Invasive Plant Ecology is an excellent collection of thought-provoking essays by an international group of scientists, researchers, and academicians discussing the challenges of invasive plants from an ecological perspective but with multidisciplinary approaches. The problems of invasive plant species have been greatly increased with modern travel and transport systems between different regions, countries, and ecozones. Due to sheer negligence, and often due to lack of proper monitoring systems, awareness, education, and training, a large number of non-native plant species are being transported and exposed to vulnerable ecosystems, thereby causing severe ecological and environmental deterioration and rapid loss of endemic species. This volume includes detailed investigations into: the factors promoting invasive plant introductions; their establishment in fragile ecosystems across the globe; the biotic and abiotic factors involved in human interventions; ecological models; case studies; interaction between non-native and alien plant species with the local flora; loss of endemic species due to severe competition from alien species for access to local available resources; efforts, strategies, and management to minimize the possibility of non-native or invasive plant introduction; and challenges of successful eradication and management programs.

The editors should be credited for performing the challenging task of tackling this timely and critical ecological issue from many different angles and for providing multidisciplinary approaches to better understanding both the biology of invasion and the management of invasive plant species. The editors and authors have convincingly demonstrated that both multidisciplinary and interdisciplinary approaches are essential and, in fact, necessary to successfully handle this complex ecological issue, which has grave ecological, agricultural, environmental, economic, and sociocultural consequences for both the natural world and human societies. The volume also discusses spatial analysis and predictive modeling of alien and non-native invasive plants with respect to specific ecosystems. Prominent examples are discussed from diverse ecosystems from the Indian subcontinent in Asia, as well as from the continents of North America (particularly the United States) and Africa. The color plates, through their excellent layout and the simplicity and elegance of their presentation, make a great contribution to the work. I hope that future editions will include more of such plates for better communicating complex research to the readers.

The volume is divided into 18 diverse chapters, including: "What makes alien plants so successful? Exploration of the ecological basis," "From species coexistence to genotype coexistence: What can we learn from invasive plants?," "Exotic plant response to forest disturbance in the western United States," "Alien plant invasion and its ecological implications," "Ecology and management of invasive plants in Africa," "Improving restoration to control plant invasions under climate change," and "Economics of invasive plant management."

Each chapter contains summary tables, graphs, images, word diagrams, schematic charts, and a comprehensive bibliography for serious and enthusiastic readers to look for further information. The authors deserve special credit for presenting complex concepts and relevant case studies, and for explaining critical issues in simple terms without compromising the technical aspect of the research. The book will be valued for its comprehensive coverage of both basic and applied models involving invasion, establishment, and competition generated by invasive species in vulnerable ecosystems and ecozones. The editors have been meticulous in including both fundamental and applied aspects of invasive plant ecology to provide an excellent platform to investigate and analyze the challenges of invasive plant control and eradication strategies. They also deserve special credit for bringing together a diverse author group of researchers, scientists, academicians, and policy makers. Some information overlap and redundancy were observed across certain chapters; however, it is not of any major concern. In any multi-authored volume, such information overlap is common when assembling different subtopics under a broad major theme or idea. In fact, one could argue that it helps to establish and reinforce important key features of the volume.

Invasive Plant Ecology is recommended for students at the undergraduate and postgraduate level, and for researchers and academics in the fields of life sciences, plant sciences, botany, biology, plant ecology, environmental science, agriculture, forestry sciences, applied botany, and applied ecology.

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Economic Botany

Bromeliads for Home and Garden

Jack Kramer

2011. ISBN-13: 978-0-8130-3544-4
Paperback, US$ 26.95. 160 pp.
University Press of Florida, Gainesville, Florida, USA

Bromeliaceae have become popular plants for windowsills. Many of the more than 3000 species are forgiving plants to forgetful owners saving on water or who neglect to ask neighbors to water during vacations. Bromeliads please their owners not just with their colorful flowers but also with their attractive foliage, which comes in many shapes, sizes, and patterns. Thus, while in the beginning *Aechmea fasciata* was the predominant bromeliad, the diversity in garden centers has increased considerably. Consequently, growth requirements of the plants and problems growing them have also diversified. To address this field, garden writers began to include bromeliads as a side note in gardening books on succulents, and in addition, a few specialized books appeared (Steens, 2003; Bromeliad Society of Australia, 2006).

Jack Kramer, an experienced garden writer, presents in his book an overview of many genera and a total of 200 species. He gives important information on their preferences and cultivation for home gardeners. The scientific background is outdated, since the author still refers to the old three-subfamily system instead of the more recently used eight-subfamily system (Givnish et al., 2007). Also, at lower ranks, significant changes in the circumscription of genera have occurred (e.g., Grant, 1995) but have not been accepted by Kramer.

The book starts with a basic introduction to the rules of nomenclature and the history of taxonomy of the family and continues with a brief description of habitats and anatomy. However, since the emphasis of the book is popularizing bromeliads for indoor and outdoor planting, the subsequent chapters give advice on what to watch out for when buying plants, how to plant them, and how to care for them. These parts give information on propagation, cold hardiness, and forcing the plants to flower. For the latter, Kramer recommends putting the plant into a plastic bag with a ripe (ethylene-producing) apple. This is a common practice but not always successful, as we know from our own research. Similarly, in general, the recommendations in the book are suited for hobby gardeners but not for scientific purposes. These introductory parts are nicely illustrated with small drawings explaining recommendations in the text.

Most of the book (more than 100 pages) consists of descriptions of various cultivated species and cultivars of bromeliads. These are arranged alphabetically, usually with two species per page; each description includes a photo, three to five lines of description, and (usually) a sentence on how and where to grow them. The photos are descriptive but, unfortunately, several of them are out of focus. Most of the information on cultivation is given in the paragraphs at the beginning of each genus and is based exclusively on the experience of the author.

The book ends with a quick-reference guide that is supposed to aid identification by giving a table with characteristic plant size, flower color, leaf color, growth habit, and exposure, although we would rather use this guide as criteria for choosing plants before buying. The glossary should be superfluous for anyone who has taken an introductory botany course.

Altogether, this is a small and informative popular science book for amateur gardeners, especially those in subtropical regions who can grow many of these species outside. It is, however, of limited value for more experienced or scientifically oriented plant growers.

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The Drunken Botanist: The Plants That Create the World's Great Drinks

Amy Stewart
2013. ISBN-13: 978-1-61620-046-6
Hardcover, US$19.95. 381 pp.
Algonquin Books of Chapel Hill, Chapel Hill, North Carolina, USA

I was intrigued by Amy Stewart's *The Drunken Botanist: The Plants That Create the World's Great Drinks* just by reading the title. Although I am a year away from my 21st birthday, I am still interested in learning about how various plants are turned into alcohol (to keep the knowledge tucked away until next year, of course). I was surprised to find that this book was not an explanation of fermentation. Instead, *The Drunken Botanist* is an immense collection of historical facts, tidbits, and vignettes rather than technical explanations of biochemical processes. It is not written like a novel but more like an encyclopedia with alphabetical entries. The book is broken down into three sections: the first about the surprisingly wide array of plants that are fermented and directly distilled into alcohol, the second detailing the herbs and spices that are used to flavor the distilled alcohol, and the third about the plants mixed with the finished alcohol to create a cocktail. Sprinkled throughout are recipes for cocktails including old standbys, like the Manhattan, and variations on classics, like prickly pear sangria. There are also tips and instructions for growing your own citrus fruits, lemon verbena, and even hops, to name a few. Stewart also debunks common misconceptions regarding various liquors. Right from the get-go, in the first chapter, she exposes the real reason why some tequila comes with a worm in the bottle—a hint: It's not to enhance flavor or increase potency.

The Drunken Botanist is definitely geared toward someone with a plant background or at least an interest in botanical sciences, which is not to say that someone who simply likes plants but knows nothing of their structure or biology wouldn't enjoy this book. Every chapter heading includes the common name, scientific name, and family name—for example, the chapter on birch includes the subheading "*Betula papyrifera*, Betulaceae (Alder Family)." Botanical terms are sometimes explained or defined, and other times not. As examples, Stewart assumes that the reader knows the meanings of "bract" and "rhizome," but explains how stomata work and the definition of dioecy. As an undergraduate research student who has only taken a serious interest in plants for the past year, I consider myself a newbie botanist. I was still able to understand all of the technical plant terminology and did not think of it as over my head.

Although it is written in a conversational tone, the book is dense—definitely not what I would call a "beach read." The sheer amount of information in each section was lengthy and sometimes hard to keep straight, especially in the chapters on widely fermented plants like grapes and wheat, although this may be because I don't have a wide knowledge of alcohol myself. Stewart is clearly very knowledgeable and did extensive research for this book—and given the volume of facts presented she does an impressive job of keeping *The Drunken Botanist* from reading like a dry textbook.

One excellent aspect of the book that shouldn't go unnoticed was the overall visual design. The cover is fantastic, with old-fashioned block serif lettering and swirling vine illustrations in a pleasing olive and sage green color scheme. The rest of the book uses the same colors, pen-and-ink illustrations, and related serif fonts, which evoked a cool, hip vibe. This, combined with the historical vignettes, definitely helped to elevate the book from just another book about plants into a bona fide botanical bible

Overall, I enjoyed reading *The Drunken Botanist* and learned a lot about the extensive array of plants that are used to make alcohols and cocktails and the stories behind them. I would recommend it for any botanically inclined person with an interest in alcohol, and not just because the book would make a useful and visually pleasing addition to any bookshelf. Because it is accessible to readers just starting out in the field, I could see this on the reading list for an upper-level undergraduate botany course. I could also imagine college juniors and seniors, newly 21 years old, picking up the book because it is about alcohol and ending up with a new appreciation for plants.

–Alexandra Boni, Department of Biological Science, Bucknell University, Lewisburg, Pennsylvania, USA

Systematics

Flora of the Cayman Islands, 2nd ed.

George R. Proctor [with the editors and staff of Kew Publishing; Orchidaceae by James D. Ackerman]
2012. ISBN-13: 978-1-84246-403-8
Cloth, US$136.00. 724 pp.
Kew Publishing, Royal Botanic Gardens, Kew, Richmond, Surrey, United Kingdom

The Cayman Islands include Grand Cayman, Little Cayman, and Cayman Brac, and together with several islets, cover an area of about 259 square kilometers, lying geographically south of Cuba and northwest of Jamaica. The first *Flora of the Cayman Islands* was published in 1984 by George Proctor, in collaboration with Martin Brunt, at the request of J. A. Cumber, then Administrator of the Cayman Islands (Proctor, 2012: 20). At that time, the known vascular flora comprised "601 native, naturalized and commonly cultivated species of which 102 were introduced" (Frodin, 2001: 289 [citing Proctor, 1984]).

George Richardson (Dick) Proctor has long been a leader in the field of Caribbean plant taxonomy; he has studied the flora of more than 50 Caribbean islands and collected over 55,000 specimens from the West Indies and Central and South America (JSTOR, 2012). In addition to his two editions of the Cayman flora, he is recognized for his excellent major contributions to Caribbean and West Indian floras (Proctor, 1953; Gooding et al., 1965; Adams et al., 1972; Proctor, 1985, 1989; Acevedo-Rodriguez and Strong, 2005) and for publications based on his outstanding fieldwork (Kass and Eshbaugh, 1993; DeFilipps, 1999; Kass, under review). Colleagues who have joined him in the field appreciate his generosity, untiring energy, and willingness to share his knowledge (Eshbaugh, 2012; Stafford, 2012).

Proctor resumed his investigations of the Cayman flora in 1991, at age 71. Encouraged by friends and associates in the Cayman Islands, he published additions and corrections (Proctor, 1996; Guala et al., 2002), and included in this 2012 edition many species found more recently by him and his colleagues; three were added as new records after the manuscript was completed (Proctor, 2012: 667–669). The history of botanical collecting in the Cayman Islands is reviewed and updated in the introduction to this new edition (see Proctor, 1994 for additional details).

Of primary importance to amateur and professional botanists and conservationists are reports of over 100 additional plant species found in the Cayman Islands that were not recorded in the first edition. The vascular flora growing without cultivation in the Cayman Islands now totals 716 species (27 pteridophytes, 1 gymnosperm, 173 monocots, and 515 dicots). Four hundred and fifteen taxa (species and varieties) of vascular plants are believed to be truly native (indigenous, not introduced by human agencies) to these islands. Of these, 28 species and varieties are endemic (confined only to these islands, list on pp. 15–16), seven of which are new species (sp. nov.), described for the first time in this updated edition of the Flora (Appendix II, p. 673). Of additional significance are the separately listed Cayman taxa (pp.16–17) that are also confined to Jamaica (17 species); Cuba (14 species); and the Greater Antilles, Cuba, and Jamaica (8 species). All taxa are characterized, and those believed to be introduced ("not indigenous") are enclosed in square brackets.

The urgency to publish this new and updated Flora stems from recent deforestation and the building of new roads and housing developments. Such events threaten extermination for many unique plant species (mentioned above), unless efforts to expand the islands' terrestrial protected areas programs can be expeditiously completed (pp. 15, 18). Proctor's book is significant because relatively few botanical investigations have been undertaken in these islands, and over half of the endemic species of the Cayman Islands are now endangered and approximately half of its indigenous species are threatened with extinction.

Plan of the Flora

In this new edition, the families of flowering plants are arranged (as they were in the first edition) according to Arthur Cronquist's (1968) classic taxonomic system, with a few exceptions, and some updating based on APG III (2009), as well as by family specialists at Kew and elsewhere (Orchidaceae, by James D. Ackerman), or by cross referencing to The Plant List (http://www.theplantlist.org). The Angiosperm Phylogeny Group (APG) strives to establish a common view on the classification of flowering plants, based mainly on evidence gained from analyses of plant DNA sequences. First published in 1998, the APG classification has been refined twice (Royal Botanic Gardens Kew, 2010). APG III was not applied to all entries in this new Flora (see editors' note on the second edition, p. 7). Instead, the editors included a table (pp. 720–724) that lists all of the orders, families, and genera used by "Proctor in this flora against the accepted order and family names currently used in APG III." More than 25 orders and 33 families differ in the molecular-based system from those used in this new Flora (based on Cronquist, 1968). A footnote to this table provides an abbreviated citation for Cronquist (1968) and APG III (2009), which are omitted from the bibliography.

The layout and color scheme that offset the descriptions make this volume easier to use than the earlier edition. Descriptions of families, genera, and species are provided in the text, together with dichotomous keys for the identification of taxa at each level. Characters used in the keys are not repeated in the descriptions, so that keys are considered an integral part of the descriptions (p. 12).

For each species, the author includes essential synonymy, common names, a brief description, localities, distributions, economic use, and if invasive, threats to the community. New taxa are described in Latin, with type specimens designated. An extensive and concise glossary readily assists the reader with botanical terminology. Indices for botanical and common names are provided. Appendix I lists 116 "Additions to the Cayman Flora" by family, and did not include *Scolosanthus roulstonii* Proctor (Rubiaceae, see Appendix II), bringing the total to 117 plants over those previously described. Appendix II provides a listing for all new taxa in this volume.

Illustrations and Photographs

The first edition of Proctor's (1984) *Flora of the Cayman Islands* included 256 text figures (black-and-white line drawings), which are all republished in this 2012 edition; two figures are unintentionally given the same numbers (Fig. 104 [=103] and Fig. 209 [=208]). The drawings were taken from original illustrations by "Mr and Mrs D. Erasmus" and Miss V. Goaman, previously published works (Fawcette and Rendle, 1910–1916; Hitchcock, 1936) "and collateral publications" (originals from Hunt Botanical Library, Pittsburgh, Pennsylvania, USA), previously unpublished drawings (prepared by "Mrs D. Erasmus" for volume 6 of *Flora of Jamaica*, held "in the Department of Botany at the British Museum [Natural History]"), and two others from a book by R. Rose-Innes (no citation given) and from the "Orchid Herbarium of Oake [*sic*—for *Oakes*] Ames Botanical Museum, Harvard University." Initials inserted at the end of each figure caption reflect the source for each drawing [e.g., (D. E.) represents "Mr D. Erasmus"].

One advantage of this second edition is the inclusion of approximately 400 color photographs: 64 color plates are inserted between pages 544 and 545 showing from six to eight photographs per plate. Each photograph, however, is identified only by family, genus, and species; photographs not taken by the author are acknowledged by the initials of the photographer, named in an earlier section of the book (p. 9). Color photos should assist both amateur and professional botanists to become better acquainted with the diversity of this unique flora.

Kass and Miller (2006) noted that evolutionary studies on islands found that species may vary greatly from their counterparts on the mainland because of different selection pressures and species isolation. Furthermore, we should not assume uniformity of species among larger islands (e.g., Cuba, Jamaica) or even between islands in the Caymans. For conservation purposes, Eshbaugh and Wilson (1996) recommended recognizing and documenting species differences that might exist for island populations in the Bahamas. Descriptions with accompanying accurate illustrations of the plants growing in situ would be an aid to this process (Kass and Miller, 2006; Kass, 2009). Photographs of Cayman Island plants that accompany the illustrations (drawn from plants growing on other larger islands) are of definite value in this respect.

Not all species are illustrated, but those that are may be accompanied by a drawing, one or more photographs, or both. For example, the cactus *Epiphyllum phyllanthus* var. *plattsii* Proctor is listed as a new taxon for this volume in Appendix II, with accompanying page number (p. 256) and plate number ("P 14"), where one finds photographs 6 and 7, depicting what appear to be the flat, thin, ultimate branches, and an oblong red fruit, respectively. Also listed in this appendix is the new taxon *Pisonia margaretiae* Proctor (p. 254, plate number omitted). Yet, the description on page 254 refers readers to "Plate 14," where indeed photographs 2–4 show what appear to be inflorescences in various states of development (reminder: the photo captions only provide the family, botanical name, and initials of the photographer). Another cactus, *Opuntia dellenii* (Ker-Gawl.) Haw. (pp. 257–258), previously known for this flora, is represented by an illustration (Fig. 90) and a photograph ("Plate 14" [no. 8, showing one obovate joint with spines]). A new endemic species of *Agave*, *A. caymanensis* Proctor, is illustrated (Fig. 7, Plate 7, no. 3–5) by a drawing identified previously as *A. sobolifera*, from Jamaica, and with which it had been previously confused (A. Stafford to L. Kass, pers. comm., 2 April 2013; Proctor, 1994: 240; 2012: 183, 184). Comparing the photographs with the drawings may elucidate my concerns for the importance of making drawings from indigenous specimens (Kass and Miller, 2006; Kass, in press).

Suggestions for and Limitations of the Flora

Readers should be aware that plant names for the photographs on the front "cover illustrations" are identified from right to left, not "left to right" as mentioned on the copyright page.

At first glance, it is not obvious that described taxa placed in brackets are not indigenous to the Cayman Islands (this information is buried in the Plan of the Flora [p. 12]). It would be helpful if the listed bracketed taxa were noted as such in captions for the Index of Botanical Names and in Appendix II; a notation such as "[ ] = not indigenous" might readily alert readers to the status of these plants.

It would be beneficial if all citations to books from which illustrations were reproduced (e.g., p. 8: Hitchcock, 1936) were listed in the bibliography, and useful to have therein the source for the first edition of the Flora (Proctor, 1984), upon which many of the descriptions and line drawings were based. Additionally, I suggest adding to the bibliography (pp. 698–699) all citations mentioned in the text (e.g., see p. 20).

The section on "environment and plant communities" with diagrams [Brunt, 1984], mentioned in the acknowledgments (p. 9), was omitted, and apparently replaced by a very brief non-illustrated introductory section on geography and phytogeography by Burton and Clubbe (pp. 13–15). The natural vegetation communities of the Cayman Islands (Burton, 2008b) and threatened plants (Burton, 2008a) were published elsewhere, and provide detailed descriptions, but a few diagrams and maps would have been helpful within this Flora.

The urgency of this project, with respect to conservation efforts for the Cayman Islands, might explain why more careful editing was circumvented. It is disappointing that such a beautifully produced volume is diminished by the rush to add the addendum, which, inserted before the appendices, is not reconciled with them, the indices, or the editors' notes. A more complete bibliography would also be worthwhile, as would more careful editing of the introductory sections, including the acknowledgments and the table of contents. Furthermore, family names in many of the plates are mislabeled (e.g., Plates 36, 45–47), photographers initials were often omitted, and some photographs are mislabeled (e.g., Plate 18, no. 7 is not *Hibiscus pernambucensis*, but is most likely [*H. tiliaceus* L.], and neither is it indigenous, nor listed in Proctor, 2012; Plate 36, no. 6 is not *Savia erythroxyloides*, but is *Buxus bahamensis*).

The hardbound copy, weighing about 3 lbs. and approximately 9.5 x 6.25 inches overall, could easily fit in a backpack, making it a valuable field guide. The many photographs, along with illustrations, should be helpful for accurate identifications, especially if an errata or corrigenda will be forthcoming.

Acknowledgments: I thank P. Ann van B. Stafford for helpful insights and correct plate and photograph identifications, and Robert Dirig for helpful discussions and suggested revisions on this review.

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–Lee B. Kass, L. H. Bailey Hortorium, Department

Florida Wildflowers: A Comprehensive Guide

Walter Kingsley Taylor
2013. ISBN-13: 978-0-8130-4425-5
Paperback, US$29.95. 576 pp.
University Press of Florida, Gainesville, Florida, USA

This medium-format field guide is a revised, expanded version of the author's 1998 work, *Florida Wildflowers in Their Natural Communities*. The book includes 752 numbered plant entries (compared to 500 in the earlier version) arranged two per page. For each, a color photograph of the plant is accompanied by a heading with the common name(s), followed by scientific name of family and species, status as native or not, a brief description of the plant, flowering time, habitat, and range within the state. Additional brief commentary and a list of synonyms are included for some taxa. Although certainly many species of the state's extensive angiosperm flora are not included in this putatively comprehensive guide, it does compare favorably to other guides of similar focus with respect to number of taxa included. Some of the color photos suffer from inadequate focus, scale, or contrast, but most are of good to very good quality. Scientific names appear to be quite up to date; background information provided is occasionally not so. (The Eocene is given as 65 million years ago; the mycoheterotroph *Monotropa uniflora* is stated to be saprophytic on tree roots.)

For plant field guides that aim to serve both the botanically informed and the nature enthusiast with limited scientific knowledge, a central issue is how to organize the species treated. Serving the latter public often means avoidance of a primarily family- or genus-based listing. Some competing guidebooks organize plants primarily by flower color, which isn't always straightforward and of little use when the plant of interest is not in flower. This book takes a different tack. The author arranges entries according to plant communities under two major categories: wetlands and hardwood-forested uplands (confusingly named, since pine woodlands are included). These categories are subdivided into eight and 11 ecological communities, respectively. Within each of those 19 communities, plant entries are organized alphabetically by family, then genus. This organization does create some difficulties in looking up a plant of interest, since many occur in more than one plant community, and with much of Florida ravaged by wanton development one often cannot discern much about the surrounding community besides whether it is gated or not. On the other hand, the author's system does compel the user to think and learn about the plants in a community context, and it must be said that the illustrated descriptions of the communities in the first part of the book go a long way in facilitating this effort.

Reasonably priced, this guide will be an important resource to amateurs and professionals alike. Anyone involved in learning about the plants of Florida will want to have a copy on hand.

–William B. Sanders, Florida Gulf Coast University, Fort Myers, Florida, USA

Biology: Organisms and Adaptations: Instructor's Edition. Robert K. Noyd, Jerome A. Krueger, and Kendra M. Hill. 2013. ISBN-13: 978-0-495-83020-7 (Paperback US$164.95) 670 pp. Brooks/Cole, CENGAGE Learning, Belmont, California, USA.

The City Natural: *Garden and Forest Magazine* and the Rise of American Environmentalism. Shen Hou. 2013. ISBN-13: 978-0-8229-4423-2 (Cloth US$35.00) 240 pp. University of Pittsburgh Press, Pittsburgh, Pennsylvania, USA.

Combating Climate Change: An Agricultural Perspective. Manjit S. Kang and Surinder S. Banga (eds.). 2013. ISBN-13: 978-1-4665-6670-5 (Cloth US$99.95) 367 pp. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.

Data Analysis in Vegetation Ecology, 2nd Edition. Otto Wildi. 2013. ISBN-13: 978-1-118-38403-9 (Paperback US$79.95) 336 pp. Wiley-Blackwell, Somerset, New Jersey, USA.

Ecological Gradient Analyses in a Tropical Landscape (Ecological Bulletins No. 54). Grizelle González, Michael R. Willig, and Robert B. Waide (eds.). 2013. ISBN-13: 978-1-118-65932-8 (Cloth US$65.00) 248 pp. Wiley-Blackwell, Somerset, New Jersey, USA.

England's Rare Mosses and Liverworts: Their History, Ecology, and Conservation. Ron D. Porley. 2013. ISBN-13: 978-0-691-15871-6 (Cloth US$40.00) 232 pp. Princeton University Press, Princeton, New Jersey, USA.

A Field Guide to the Flowers of the Alps. Ansgar Hoppe. 2013. ISBN-13: 978-1-907807-40-4 (Paperback US$32.99) 192 pp. Pelagic Publishing, Exeter, United Kingdom.

Flore des Bryophytes du Québec-Labrador. Volume 1: Anthocérothes et Hépatiques. Jean Faubert. 2012. ISBN-13: 978-2-98132600-3 (Cloth CAD$80.00) 356 pp. Société québécoise de bryologie du Québec, Saint-Valérien-de-Rimouski, Québec, Canada.

The Genus Betula: A Taxonomic Revision of Birches. Kenneth Ashburner and Hugh A. McAllister (eds.). 2013. ISBN-13: 978-1-84246-141-9 (Cloth US$112.00) 431 pp. Royal Botanic Gardens, Kew, distributed by The University of Chicago Press, Chicago, Illinois, USA.

An Introduction to Population Genetics: Theory and Applications. Rasmus Nielsen and Montgomery Slatkin. 2013. ISBN-13: 978-1-60535-153-7 (Cloth US$62.95) 298 pp. Sinauer Associates, Inc., Sunderland, Massachusetts, USA.

The Kingdom of Fungi. Jens H. Petersen. 2013. ISBN-13: 978-0-691-15754-2 (Cloth US$29.95) 272 pp. Princeton University Press, Princeton, New Jersey, USA.

Measurements for Terrestrial Vegetation, 2nd Edition. Charles D. Bonham. 2013. ISBN-13: 978-0-470-97258-8 (Cloth US$89.95) 264 pp. Wiley-Blackwell, Somerset, New Jersey, USA.

Plant and Animal Endemism in California. Susan P. Harrison. 2013. ISBN-13: 978-0-520-27554-6 (Cloth US$49.95) 189 pp. University of California Press, Berkeley, California, USA.

Plant Roots: The Hidden Half, 4th Edition. Amram Eshel and Tom Beeckman (eds.). 2013. ISBN-13: 978-1-4398-4648-3 (Cloth US$199.95) 848 pp. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.

The Savage Garden: Cultivating Carnivorous Plants, revised. Peter D'Amato. 2013. ISBN-13: 978-1-60774-410-8 (Paperback US$25.99) 384 pp. Ten Speed Press, Emeryville, California, USA.

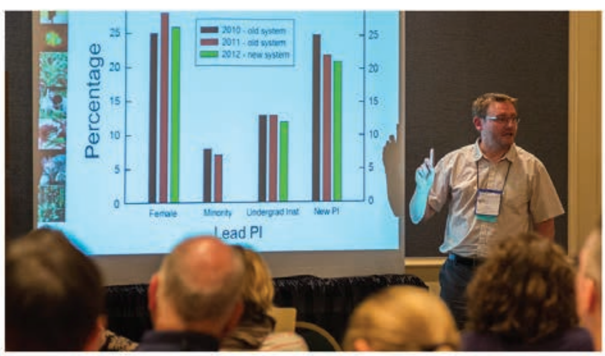
Wildflowers of the Mountain West. Richard M. Anderson, JayDee Gunnell, and Jerry L. Goodspeed. 2012. ISBN-13: 978-0-87421-895-4 (Spiralbound US$24.95) 302 pp. Utah State University Press, an imprint of University Press of Colorado, Boulder, Colorado, USA.

Botany 2013 was by your account - a major success.

Some images from the meeting and comments from the survey! Thank you, All!

This was my first botany conference and it was a great experience.

Nice diversity of talks, with important sessions on new technologies and methods.

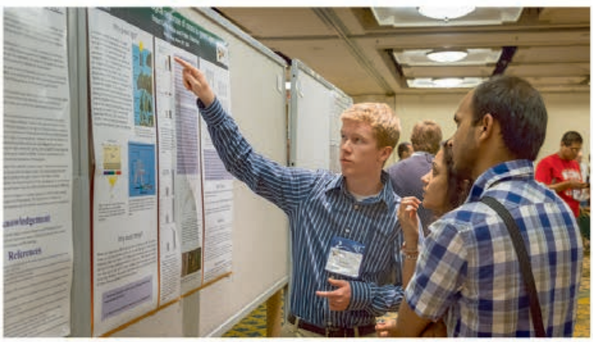


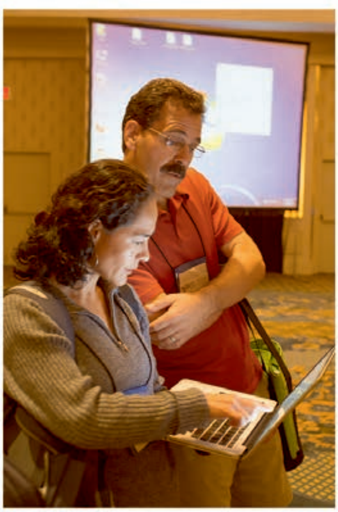
Great hotel, great venue city, great organization. Pleasantly surprised by BSA's increased proactivity, increased openness, and increased look to the future of botany.

Enjoyable. Great energy and spirit among those attending!

BOTANY 2013

I was busy the whole time either presenting or judging or making connections with colleagues with whom to launch new projects...enjoyable and intensely-filled time.





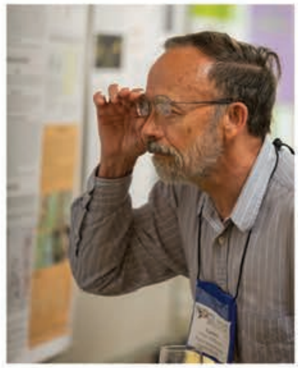
I would rank New Orleans as one of the best venues ever. The only negative was that it was a bit expensive, but overall, it is a great place. The hotel/conference center was convenient and the location in the city was also nice. And, New Orleans is simply fascinating!

It was a great congress, with many speakers and posters. It was a good opportunity to network.

A great meeting to take undergraduates to

It was a great experience because of the people I get to meet there. I found the presentations to be interesting, however, the best experience for me was to be able to interact with professionals from different universities and learn about them.

I really thought this was a great meeting - the Keynote speaker on Trees and Outreach was absolutely fantastic. I met a lot of people, there was an abundance of great food outside of the hotel, and New Orleans is fun!

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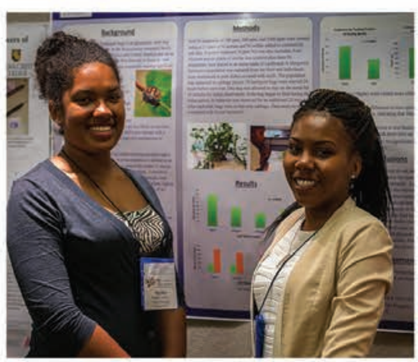

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The Botanical Society of America is a membership society whose mission is to: promote botany, the field of basic science dealing with the study & inquiry into the form, function, development, diversity, reproduction, evolution, & uses of plants & their interactions within the biosphere.

PLANT SCIENCE BULLETIN FEATURED IMAGE

Bayou Rebirth's mission focuses on restoring Louisiana's wetlands, and its history dates back to 2007. Bayou Rebirth has a dedicated staff, relationships with a wide variety of sponsors and partnerships, and a dedicated Board of Directors all working towards preserving and restoring Louisiana's wetlands. See more at: http://www.bayourebirth.org/about-us/#sthash.cIYj05qH.dpuf

In an effort to increase public awareness of coastal land loss and the need for urban resilience to climate change impacts, Bayou Rebirth seeks to bring together, educate, and empower residents of and visitors to South Louisiana through hands-on wetlands restoration and stewardship projects. - See more at: http://www.bayourebirth.org/about-us/mission/#sthash.n0CfPhj3.dpuf

Botany 2013 is proud of the volunteers who helped and donated their time to this very worthy cause. Story and more pictures on page 83.

Bayou Rebirth