



# PLANT SCIENCE BULLETIN

SPRING 2022 VOLUME 68 NUMBER 1

A PUBLICATION OF THE BOTANICAL SOCIETY OF AMERICA



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## IN THIS ISSUE...



Welcome to new APPS Editor-in-Chief,  
Briana Gross...p. 4



Targeted plant collection by undergrads  
& citizen scientists to understand plant  
distribution...p. 24



Discovering the microscopic world of live  
tree bark...p. 12

# FROM THE EDITOR

Greetings,

Spring 2022 is upon us. Writing for posterity, I feel I must note a few world events. Since our Fall issue, the United States has endured a spike in COVID cases. Fortunately, reported case numbers have fallen dramatically since and, in Omaha at least, we are seeing some of our lowest numbers in a year. Anxiety over the virus and the presence (or absence) of safety protocol continue to affect many of us. Just over three weeks ago, Russia invaded Ukraine. I've heard from both Russian and Ukrainian colleagues expressing anger and dismay over this turn of events. We at *PSB* send our deepest sympathies to our readers directly affected by violence either there, or anywhere else in the world.



We have several articles and special features in this issue that I hope you will enjoy. We welcome a new Editor-in-Chief of *APPS*, and you can read about Briana Gross' vision for that journal. We also say goodbye to a large cohort of Botanists we have recently lost in our *In Memoriam* section. Please take a moment to read about their extraordinary lives and careers.

Excitement is building over Botany 2022. This will be the first hybrid meeting in BSA history. I am looking forward to seeing many of you in-person in Anchorage.

Sincerely,

A handwritten signature in cursive script that reads "Mackenzie".

## ***PLANT SCIENCE BULLETIN*** **Editorial Committee** **Volume 68**



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# TABLE OF CONTENTS

## SOCIETY NEWS

BSA Welcomes Briana Gross as New <i>APPS</i> Editor-in-Chief.....	4
Clade Biology, Phylogenetic Biology, and Systematics.....	7

## SPECIAL FEATURES

Discovering the Microscopic World of Live Tree Bark .....	12
Filling in the Gaps: Targeted Plant Collection by Undergraduates and Citizen Scientists to Better Understand Plant Distribution.....	24
The Future of Botany: Educating for a Diverse and Inclusive 21st-Century Workforce.....	32

## SCIENCE EDUCATION

PlantingScience Digging Deeper Research Published .....	42
Update on PlantingScience .....	42
Life Discovery Conference 2021 .....	45
Updated Teaching Resources.....	45

## STUDENT SECTION

Roundup of Student Opportunities.....	46
---------------------------------------	----

## ANNOUNCEMENTS

In Memoriam Sherwin Carlquist (1930–2021).....	66
In Memoriam Jack Lee Carter (1929-2020).....	67
In Memoriam Alan Graham (1934–2021) .....	70
In Memoriam William Louis Stern (1926–2021).....	73
In Memoriam Ronald L. Stuckey (1938–2022).....	77
In Memoriam Leonard Thien (1938–2021) .....	81

## MEMBERSHIP NEWS

2021 Gift Membership Drive Results and Drawing Winner.....	85
Introducing Botany360: The BSA Community Event Calendar .....	86
BSA Award Opportunities.....	87
Did You Know? .....	87

BOOK REVIEWS.....	88
-------------------	----

BSA YEAR IN REVIEW .....	INSIDE BACK COVER
--------------------------	-------------------





## BSA Welcomes Briana Gross as New *APPS* Editor-in-Chief

*Briana Gross recently took on the role of Editor-in-Chief of Applications in Plant Sciences (APPS), the BSA's first fully Open Access journal, publishing newly developed, innovative tools, protocols, and resources in all areas of the plant sciences. We spoke with Dr. Gross about her vision for the journal.*



### **What inspired you to apply to be Editor-in-Chief at *APPS*?**

I was lucky to be nominated by one of my mentors, Susan Kephart. I had seen the advertisements for the Editor-in-Chief position and considered applying, but I didn't really dig in until being nominated. Once I gave myself time to think about it, I realized how excited I was about *APPS* and remembered how much I enjoy editorial work. This was also an ideal time in my career to take on this role, so I felt ready to commit. I am relaying the fact that I was nominated because I think it's important for me (and others) to acknowledge the power of nominating others for positions that we think they are qualified for, and I hope that I can "pay it forward" in the future.

### **How would you characterize your editorial philosophy?**

At an immediate, personal level, I want the authors, reviewers, and readers who interact with *APPS* to leave with a positive impression

of the journal, even when decisions might not go in an author's favor. At a broader level, it is the responsibility of the Editor-in-Chief to be mindful of the direction of the journal and plan strategically for its success in cooperation with the editorial board and editorial staff. My objective in this capacity is to work to communicate our intentions transparently and create an environment where all our community members feel heard while still moving *APPS* forward.

**Many organizations, including the BSA, have made it a priority to expand opportunities for people in underrepresented groups. How do you envision supporting and expanding diversity and inclusion in *APPS*? How do you view the opportunities and challenges of heading up an Open Access journal, while furthering diversity, equity, and inclusion?**

Thanks to the work of previous Editor-in-Chief Dr. Theresa Culley, the editorial board, and the editorial staff, *APPS* already has a good start toward expanding opportunities for publication through increasing the representation among its editors. However, there is still room for us to expand by reaching out to minority-serving institutions in the United States and to botanical societies around the world. These efforts will not bear fruit immediately, but it is time to plant the seeds now and cultivate these relationships so that authors from these groups know that *APPS* is a supportive publication venue. Publishing an Open Access journal is a double-edged sword. We make our publications available to anyone with internet access, but this comes at a cost to authors that is not always backed by their institutions or funding sponsors. Thus, we can expand opportunities through making science a common commodity, but we have to find a way to back that cost. My long-term objective is to develop a comprehensive backstop of funding sources to help cover the publication costs for articles that are appropriate for *APPS* to help fill this gap.

**As *APPS* approaches its 10-year publication anniversary, this is a time to reflect on achievements while looking to the future. What do you see as strengths of the journal and goals for the next 10 years?**

*APPS* has so many strengths: the quality of the publications in *APPS* is high and it has continued to increase over the years, it has a

great reputation in the botanical community as a reliable resource for new protocols and software, and it integrates across the diversity of fields of plant science. In the next 10 years, I want to see *APPS* as the destination for authors and readers interested in plant genomics (both resources and software) and the continually evolving catch-all of “big data” in botany, ranging from herbarium digitization to ecological modeling for plant communities. Beyond the subject matter that we cover, which will inevitably evolve in the next decade, my goal is for *APPS* to increase its profile in the botanical community so that we are the destination of choice for any new methods in plant science. As a young journal, we have enormous potential, and I know that we have capacity and ability to facilitate excellent experiences for authors, editors, and readers as we grow.

***APPS* is proud to be a Society journal. How do you think *APPS* can best serve members of the BSA community (and beyond), and why do you think it’s important for BSA members to support their Society publications?**

*APPS* can serve its members by being mindful and responsive to their needs, while also making sure that the journal continues to grow its impact factor and feature high-quality publications. I hope that I can learn more about what our members want and how we can provide this every year going forward. We also strive to give authors a great experience



when they send their work to us. On the flip side, we depend on our members to send us their work and to promote *APPS* to colleagues who might not be aware of us yet. We are all part of a team, and as a member-owned Society we all benefit from small actions that support our publications. If each of our members thought of *APPS* as the primary target for the new method they cooked up in their labs, we would be happy to see those submissions and I think that the ultimate publications will benefit from the excellent reputation of the journal.

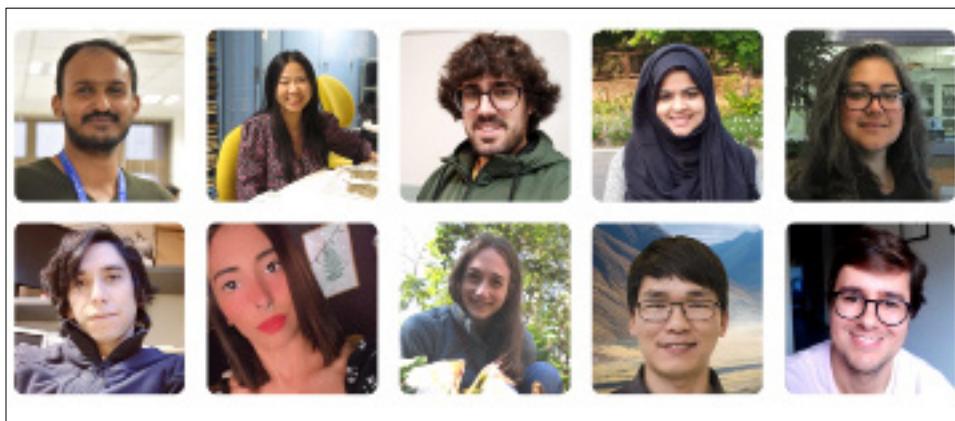
### **What are you most looking forward to as Editor-in-Chief?**

There are many different things that I like about writing and editing, and serving as Editor-in-Chief will be enjoyable for those reasons. However, one of the main things that I look forward to is working with smart, talented botanists who care about their work and have great ideas for the field and for *APPS*. Working with enthusiastic, intelligent colleagues is one of the best things we can experience in our professional careers, and I think that serving as Editor-in-Chief for *APPS* is a place where I can experience this to the fullest.

## **NEW EARLY CAREER ADVISORY BOARD (ECAB) FOR 2022-2024**

The BSA's Early Career Advisory Board (ECAB) is a group of early-career botanists that engages with and advises the editors of the *American Journal of Botany*, *Applications in Plant Sciences*, and the *Plant Science Bulletin* in a number of ways, including recommending timely topics for review papers, identifying papers in pre-print archives that may be appropriate to publish in our journals, and advising on issues of importance to the publications team.

We had a tremendous response to our recent call for students and postdocs to join the ECAB, and we are grateful to all who applied. We are pleased to officially welcome the new group!



Row 1: Ajith Ashokan, Liming Cai, Mario Blanco-Sánchez, Urooj Fatima, Ana Flores

Row 2: Jorge Flores, Catalina Flores-Galván, Shelly Gaynor, Huasheng Huang, Luiz Rezende

To learn more about the 2022-2024 ECAB Members, see <https://botany.org/home/publications/ecab.html>.

# Clade Biology, Phylogenetic Biology, and Systematics

Address of the Incoming BSA president  
Michael Donoghue, with Erika Edwards

In his incoming BSA presidential address at Botany 2021, Michael introduced the phrase “clade biology.” The idea was to draw attention to an approach that the two of us have been thinking needs more attention, and which we think differs importantly from the area now widely referred to as “phylogenetic biology.” How do these two differ? Clade biologists are those among us who obsess over some particular group of organisms, wanting to know as much about them as possible. They are fascinated to learn any little thing about these organisms, no matter how inconsequential this may seem to others. They tend to work on their organisms for a long time (often over an entire career), and come at them from multiple angles (functional morphology, development, ecology, biogeography, etc.). Of course, their work tends to be organized phylogenetically,

and their knowledge of relationships may eventually yield species delimitations and a phylogenetic classification system, but in our view these are natural outcomes of clade biology, not its primary objectives. Clade biologists tend naturally to build teams of collaborators, drawing in other disciplines as they take deep dives into one aspect or another of the biology of their organisms. If a clade biologist has the good fortune of training students, their students might become engaged in some dimension of the research and might then take that along to their own labs, in which case teams can expand through multiple labs and academic generations. Over the years, the group of organisms might ascend to the level of a “model clade.” Like model species (think *Arabidopsis thaliana*), these can then serve as vehicles for testing hypotheses of all sorts, taking full advantage of the wealth of accumulated knowledge. But in this case, they are mostly used to test hypotheses concerning patterns and processes at the level of whole clades.



**By Michael J. Donoghue & Erika J. Edwards**

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Phylogenetic biologists, in our view, take a different approach to understanding clade-level phenomena. They tend to take a hypothesis-testing approach from the outset, focusing on a particular question rather than on a particular clade, such as the evolution of dioecy or shifts in the rate of diversification. They often assemble very large phylogenetic

trees (e.g., harvesting data from sources such as GenBank), with multiple instances of dioecy, for example, scattered throughout. Alternatively, they may assemble and compare phylogenetic trees of multiple individual clades that include dioecious species. In many cases, data on the trait (or traits) under study are gathered not from nature but from surveys of the literature, or perhaps from specialized trait databases. The many other details of the organisms under study—the ones that would fascinate the clade biologist—are mostly viewed as (or assumed to be) irrelevant to the particular phenomenon under investigation. Phylogenetic biologists also have a tendency to move from one problem to another during their careers, switching from one group of organisms to another as appropriate. That is to say, they are not so deeply committed to working on one group of organisms for a long time. They collaborate with clade biologists and experts from other disciplines, as necessary, but these alliances change as they move from one suite of traits or clade to another. And, to the extent that their studies involve students, the threads that pass from one generation to the next tend to revolve around particular methodologies.

Are you a clade biologist or a phylogenetic biologist? Of course, you don't have to be either one—there are plenty of other things to be—and you could certainly be both. We have purposefully set these out as two exclusive categories, but in actuality there's a continuum between them. It's also quite possible to be a clade biologist who occasionally ventures into phylogenetic biology. We think we've done this during our own careers. It's less possible, we think, to go the other direction because, almost by definition, it's hard to dabble in clade biology, or at least to do it very

effectively, without pretty complete devotion to a particular clade, or possibly a few different clades over the course of a lifetime.

Where is “systematics” in all of this? We suspect that many BSA members identify as systematists, although this may be less so among younger members—at least, in our recent experience, postdocs and graduate students don't identify as strongly with systematics as they used to. To be sure, they are happy to publish in journals with the word systematics in the title, such as *Systematic Biology*, but they don't really see themselves as systematists.

Traditional systematics doesn't map very neatly onto phylogenetic biology, as we delimit this here, although we suspect that some who identify as systematists would also consider themselves to be (at least partly) phylogenetic biologists. Systematics comes much closer, we think, to clade biology, especially in as much as training in systematics often begins with the choice of a group of organisms on which to become the world's expert. On the other hand, we suspect that our definition of clade biology will seem overly broad to many systematists in the sense that it doesn't specifically highlight species delimitation and classification, which have long been the bread and butter of systematics. In our view, species delimitation and naming are critical elements of clade biology, but our definition puts a greater emphasis on understanding the complete biology of the organisms in question (including work at the intersection of molecular biology, development, physiology, ecology, etc.), whether or not this knowledge bears very directly on species delimitation or classification (although, naturally, it very often will).

**Box 1.** Where does “systematics” fit in? Of these three options, we prefer number 3.

**1. Clade Biology (= Systematic Biology)**  
**Phylogenetic Biology**

**2. Clade Biology**  
Systematic Biology (species delimitation, classification)  
**Phylogenetic Biology**

**3. Systematic Biology**  
Clade Biology  
Phylogenetic Biology

If one did wish to equate systematic biology with clade biology (i.e., if these were viewed as one and the same; Box 1, option 1), which name would we choose for this field? One might argue that we don't need a new term—we should just stick with systematics for this field. On the other hand, we think that clade biology has a distinct advantage in that it refers unambiguously to the object of study: clades. In this sense it is comparable to terms such as “population biology,” “cell biology,” etc., where the object of study is clearly named. “Systematics” is ambiguous on this score, as “system” itself is pretty vague and all-encompassing. So, if we had to choose, we think that clade biology would be the better choice.

Another possibility would be to make a hierarchy out of these disciplines (Box 1, options 2 and 3). But does clade biology naturally encompass phylogenetic biology, or vice versa? We think not. As for “systematics,” we see two possibilities. One would be to use it to signify the subdiscipline within clade biology focused squarely on species discovery and classification. Another possibility, which we prefer, would be to retain systematics for the more inclusive field that encompasses both clade biology and phylogenetic biology. In

any of these cases, we want to emphasize that we see both clade biology and phylogenetic biology as totally worthwhile and necessary endeavors. There's no better or worse here—just alternative approaches to studying clade-level phenomena. Which way you lean just depends on what you find most satisfying.

Of course, it's perfectly okay to not worry at all about where you fit into this schema, and to chart your own path. And, in doing so, you might find yourself flirting with other somewhat ill-defined terms, such as “integrative biology” or “comparative biology.” We won't tackle these here, except to note that integrative biology aligns pretty well in some respects with clade biology, although some who identify with this term are not so focused on individual clades. Likewise, comparative biology aligns in some respects with phylogenetic biology in our sense of the word. It's a confusing landscape of terminology, to be sure.

Our main point here is that it's worth recognizing clade biology as a distinct endeavor, with its own peculiar and enduring scientific value. To illustrate this, we'll briefly highlight the work of our recently deceased zoological colleague, David Wake.

Dave, along with his spouse and colleague, Marvalee, both of UC Berkeley, devoted their careers to understanding amphibians, but especially salamanders, and especially lungless salamanders (Plethodontidae). If you haven't followed this work, you should look into it, and you'll find one discovery after another grounded in their deep commitment to, and knowledge of, these organisms, built up over more than five decades (Griesemer, 2013). James Hanken (quoted in Sanders, 2021), long the Director of Harvard's Museum of Comparative Zoology, described Dave Wake in these words:

“He chose a particular lineage of organisms—in this case, the family Plethodontidae—and pursued it in all respects in order to understand how the group diversified and why it did the way it did. It was molecules to morphology to ecology to behavior to development, overlaid by taxonomy—his was a deliberate conviction that in order to really understand the evolution of organisms, you have to focus on a particular group and get to know it extremely well.”

This captures perfectly the way that we're thinking about clade biology: complete immersion in a group of organisms, studied from every possible angle. Add to this a team-building mentality and lots of enthusiasm and you're in for a lifetime of pleasure and discovery. And the beauty of such a long-term commitment is that it leads naturally to discoveries of very broad significance. As Michael Nachman (quoted in Sanders, 2021), Director of the UC Berkeley Museum of Vertebrate Zoology, put it: “Salamanders were his love and passion, but he was really a deep thinker who used salamanders as an entry way to thinking about the biggest questions in evolutionary biology.”

Clade biology, done well, starts with some organism-of-interest problem, but works its way out to questions and answers in realms that were never anticipated. Wake, for example, was at the epicenter of the formation of the field of evolutionary developmental biology, and of the study of parallel and convergent evolution, and of speciation (e.g., “ring species” in *Ensatina*). He also alerted the world to the global decline of amphibian populations. All of this flowed naturally from his deep knowledge of salamanders.

One last thought concerns the career choices faced by students and early-career scientists, who may consider a long-term commitment to a clade—with uncertain outcomes—to be too risky in this day and age. We certainly understand this worry but would offer the following advice. If you are passionate about a group of organisms, keep that passion alive even as you pursue other things that might lead to more immediate accomplishments. We think you'll find that the deep knowledge that you accumulate will provide you with a special lens through which to view biological phenomena of all sorts, and will serve as an unending source of fresh ideas. Get to know a group of organisms “extremely well,” we're certain you won't regret it!

Our overall conclusion is that clade biology is a highly productive way of knowing, which provides a necessary compliment to other approaches, including what we have distinguished here as phylogenetic biology. We are confident that we won't lose this approach so long as at least some people continue to obsess over particular groups of organisms, which seems inevitable. However, what we must do is to properly value, encourage, and support this approach, and consciously improve it not just for our own happiness but for the betterment of science at large.

## ACKNOWLEDGMENTS

We are very grateful to the BSA for the opportunity to present these views, and to the many students and colleagues who have discussed these topics with us over the years.

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Sanders, R. 2021. David Wake, a prominent herpetologist who warned of amphibian declines, is dead at 84. *Berkeley News*, May 4, 2021. Website: <https://news.berkeley.edu/2021/05/04/david-wake-a-prominent-herpetologist-who-warned-of-amphibian-declines-is-dead-at-84/>.



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# SPECIAL FEATURES

## Discovering the Microscopic World of Live Tree Bark

A Model Instructional Experience for Students and Teachers  
Using a Virtual iAdventure, Teacher Preparation Guide,  
Student Worksheets, and Moist Chamber Cultures

### RATIONALE FOR INSTRUCTIONAL EXPERIENCE

Patricia (Trish) A. Smith, now retired, was a seventh-grade Life Science teacher at Warrensburg RVI Middle School (WMS), at Warrensburg, MO during 2004–2007. Her expertise in finding grant funds supported her laboratory classroom activities with extramural funding. These grant funds came from the Missouri Department of Elementary and Secondary Education and local private organizations. She shared her classroom



**Figure 1.** Trish Smith in her classroom laboratory wetting moist chamber tree bark cultures. Note labeled plastic Petri dishes with moist chamber tree bark ready for observation. (Photo by H. W. Keller.)



By **Harold W. Keller and Ashley Bordelon**  
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and laboratory experiences on how live animals and trees were integrated into her laboratory activities in presentations given nationally and in Missouri (Figure 1). Her connections to the University of Central Missouri (UCM) led her to explore a possible National Science Foundation-Research Experience for Teachers (NSF-RET) grant

as a supplement to the iAdventures that was already part of her synergistic laboratory experiences. The intent of the NSF-RET was to provide funds for professional development targeted for teachers K–12 on the cutting edge of science, to strengthen partnerships between institutions of higher learning and local school districts. She consulted in 2004 with then NSF grant-holder, and Principal Investigator, Harold W. Keller at UCM, who had an NSF grant titled “Biodiversity and Ecology of Tree Canopy Biota in the Great Smoky Mountains National Park.” The objectives of this tree canopy biodiversity research project were chronicled in previous publications and will not be repeated here (Keller, 2004, 2005, 2019; Smith and Keller, 2004; Kilgore et al., 2008). This partnership appeared to be a good fit for an NSF grant proposal to the Division of Environmental Biology, Biodiversity Surveys and Inventories Program.

Prospective applicants for RET grants must prepare a cooperative grant proposal after first consulting with the appropriate NSF Program Officer. This grant proposal application included a three-page descriptive narrative, a two-page teacher curriculum vitae, a prepared budget, and justification for up to a limit of \$10,000. This RET supplemental funding application was submitted electronically through the grant-holder’s university by NSF Fastlane.

Current application instructions are included in opportunity announcement NSF18-089. Some of these details have changed (for example, teacher budget costs are now up to \$15,000). The following quotation represents in part current NSF priorities: “Another goal of the RET supplement activity is to build collaborative relationships between K-12 science educators and the NSF research

community. BIO is particularly interested in encouraging its researchers to build mutually rewarding partnerships with teachers at urban or rural schools and those in school districts with limited resources.”

## EXPERIENCING TREE CANOPY BIODIVERSITY IN GREAT SMOKY MOUN- TAINS NATIONAL PARK: CONNECTING SEVENTH GRADE STUDENTS THROUGH AN iADVENTURE

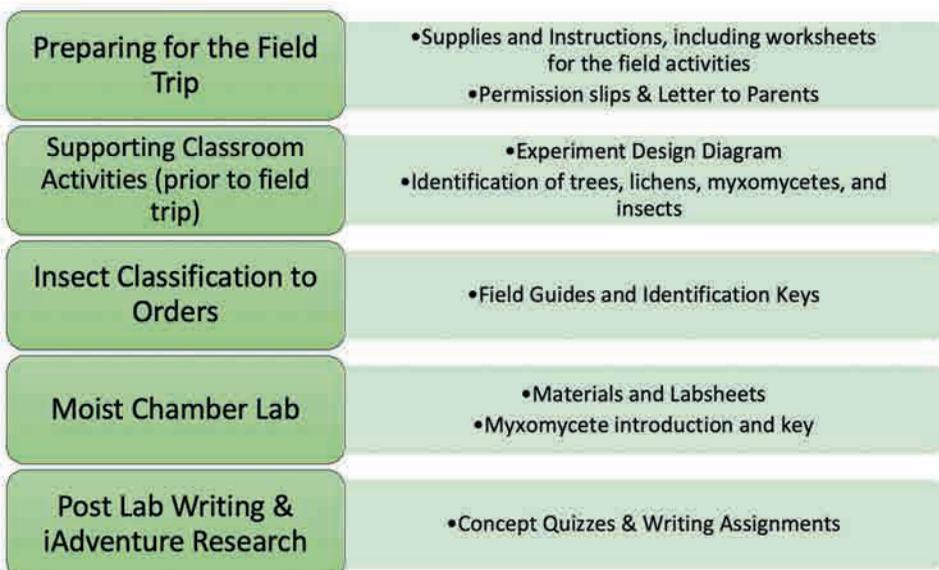
This activity was part of the virtual field tree canopy experience in the Great Smoky Mountains National Park (GSMNP - iAdventure) during 2004. The field collection of live tree trunk bark samples of Eastern Red Cedar (*Juniperus virginiana*) trees took place at Pertle Springs, the land laboratory for UCM (see Teacher Preparation Guide and Student Worksheets below). Seventh-grade life science students from WMS were bused to Pertle Springs where they collected live tree bark samples and prepared moist chamber bark cultures in the classroom laboratory. Many life forms, including myxomycetes, were observed during laboratory class sessions.

The iAdventure live link with all its web content was removed from the Warrensburg Middle School site when Trish and Stan Smith retired. However, the papers, images and documents and original Uniform Resource Locator were preserved by the authors. In September 2021, Jason Best,

the Director of Biodiversity Informatics at the Botanical Research Institute of Texas (BRIT), was able to revive the original website through GitHub ([https://britorg.github.io/GSMNP\\_iAdventure](https://britorg.github.io/GSMNP_iAdventure)). Interested persons can now access and experience the full content of the iAdventure in GSMNP, as well as the Teacher Information Page that has Student Worksheets related to the collection of field samples. The intent is to extend the benefits of these field experiences for students and teachers worldwide through this linked inquiry-based iAdventure available as an interactive web-based activity. Additionally, historical snapshots of the iAdventure site can be accessed through Archive.org at: [https://web.archive.org/web/2016\\*/http://warrensburg.k12.mo.us/iadventure/gsmnpiadventure/](https://web.archive.org/web/2016*/http://warrensburg.k12.mo.us/iadventure/gsmnpiadventure/).

## SYNOPSIS OF iADVENTURE, TEACHER PREPARATION GUIDE, AND STUDENT WORKSHEETS CONTENT

In the summer of 2004, Trish and Stan Smith arrived at GSMNP, pitched a tent, and recorded daily activities of the tree canopy research team as part of the iAdventure. *Exploring Life in the Forest Canopy* highlights and tracks the activities of five undergraduate UCM students (Amber, Ashley, Cheryl, Erin, and Tommy) as they participate in the tree-climbing school at Pertle Springs and the field experience climbing giant trees in the GSMNP collecting tree trunk bark samples. On the iAdventure website, visitors can explore topical headings such as *Research Objectives*; *GSMNP All Taxa Biodiversity Inventory*, with geographical area description; *Field Trip Organization Pre-trip Planning*; *Knott Clinic*; *Tree Climbing School*; *Meet Charly Pottorff*, professional arborist;

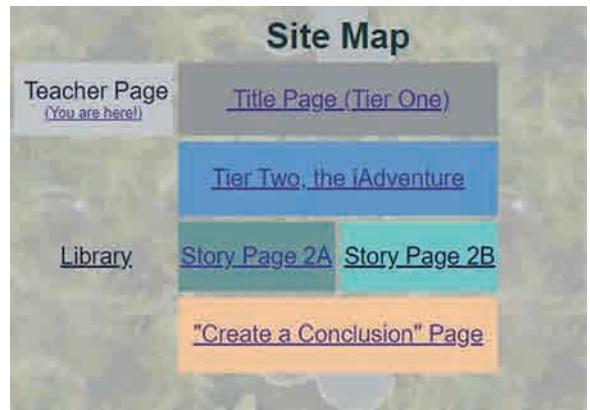


**Figure 2.** Summary of resources provided for teachers on the Teacher Information Page, iAdventure website.

meet Dr. Steve Wilson, entomologist world authority on plant hoppers; meet Dr. Joe Ely, biometrician and plant ecologist; *Field Work*, climbing trees and collecting bark samples, as well as preparing and raising insect flight intercept canopy traps; *Life at the Research Station*; about Trish and Stan Smith; and *Stories from the Field*, about the discovery of a new tree canopy myxomycete species, *Diachea arboricola*, by Melissa Skrabal, among others.

The Teacher Information Page has a list of resources needed, as well as a list of questions for students about their observations of the iAdventure. It also includes links to worksheets that provide more detailed information about how to prepare for the field trip, as well as information about lichens, myxomycetes, and insects (Figure 2). Some examples included a *List of Field Tasks*; *Supply List*; *Tree Tags*; *Field Task Instruction Sheets: Meadow Sweepers*; *Canopy Catchers*; *Barking up the Right Tree*; *Myxo-O-Masters*; *Red Cedar Database Sheet*; *Lichen Log*; *Tree Sleuths*; *Entomology Worksheet*; *Insect Identification Key*; *Moist Chamber Laboratory Supplies* (used for preparation of moist chamber cultures); *Bark pH Procedure Document*; *Examination of Moist Chamber Cultures Labsheet*; and *Key to the Myxomycete Orders*, among others. Lectures describing the illustrated myxomycete life cycle, color images of myxomycete fruiting bodies using Smart Board presentations, and question-and-answer sessions enabled students to interact with the presenter. References were available for student reading and picture keying of myxomycete fruiting bodies observed in moist chamber cultures (Keller and Braun, 1999).

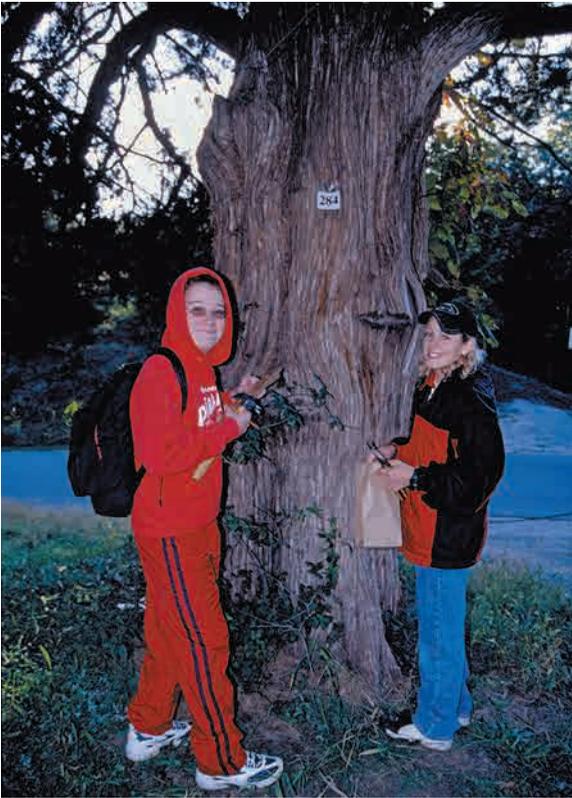
The two main student activities are nested under the Title Page (Tier One) and iAdventure (Tier Two) (Figure 3). The Tier 1



**Figure 3.** Snapshot of the 'Site Map' of the iAdventure website

iAdventure website allows worldwide access to the tree canopy field experiences in GSMNP and the parallel field research at Pertle Springs. This was a problem-solving activity that helped students determine the direction and outcome of a content-rich storyline using resources available on the internet, particularly resources providing real-world data and primary documents. Participating students should experience the three phases of research emphasized in the original GSMNP NSF grant: the Adventure Phase (tree climbing using ropes and collecting bark samples for moist chamber cultures (Kilgore et al., 2008); the Laboratory Phase (sample sorting and preparation of moist chamber cultures); and the Publication Phase (poster and oral platform presentations for local, regional, and national scientific meetings).

The Tier 2 site emphasizes the collection of live tree trunk bark of Eastern Red Cedar, American Elm (*Ulmus americana*), and White Oak (*Quercus alba*) at Pertle Springs. Students were divided into four groups and then subdivided into task groups of one or two students (Figures 4 and 5). UCM faculty



**Figure 4.** *Two seventh-grade WMS students collecting trunk bark samples from a live Eastern Red Cedar tree at Pertle Springs. Note tree tag number, collecting gear, and students enjoying this field experience. (Photo by H. W. Keller.)*

and students from the Biology Department, along with student parents, assisted with field collections. Six groups of 20 WMS students were transported to Pertle Springs for one-hour field trips on September 28 and 29, 2004, for a total of 240 students. Safety of the seventh-grade WMS students was a priority. Therefore, they did not climb trees, use knives, or shoot slick lines with the Big Shot... much



**Figure 5.** *Author and student measuring tree trunk diameter of Eastern Red Cedar tree at Pertle Springs. Note student on ground recording tree data. (Photo by T. Smith.)*

to their dismay! Tree bark samples were used to prepare moist chamber cultures so students could observe a miniature ecosystem composed of myxomycetes, fungi, lichens, mosses, liverworts, green algae, cyanobacterial algae, myxobacteria, tardigrades, insects, and nematodes, among others. This is only an overview of the two tiers; more information is available on the website.

## INSECT FLIGHT INTERCEPT TRAPS

Steve Wilson at UCM was in charge of the aerial installation of the Sante insect flight intercept tree canopy traps at GSMNP, Big Oak Tree State Park, and Pertle Springs (Figure 6). Students assisted in raising the fine-meshed canopy traps with two open pyramid structures (9 feet high by 4 feet wide) with a top and bottom 500-mL collector bottle (killing jar) filled with 70% isopropyl alcohol. This canopy trap was tethered to a horizontal branch at 50 to 60 feet for five days. Top canopy collection bottles tended to trap insects that hit the trap then climbed upward such as leafhoppers, tree hoppers and planthoppers, and moths; flies and beetles tended to hit the trap and drop downward into the bottom bottle (Wilson et al., 2003). Students also collected from ground sites using sweep nets. The collected insect specimens were used to perfect the taxonomic keys and create a basis for understanding diversity and adaptation.



**Figure 6.** *Flight intercept tree canopy insect trap installed in a tree at Pertle Springs. (Photo by H.W. Keller.)*

## PERTLE SPRINGS FIELD COLLECTIONS AND LABORATORY PREPARATION OF MOIST CHAMBER CULTURES USING LIVE TREE TRUNK BARK

General credit for the use of moist chamber bark cultures from living trees goes back to the early 1930s, when tiny species of myxomycetes new to science were discovered by graduate student Henry C. Gilbert working under the supervision of Professor Dr. George W. Martin at the University of Iowa Mycological Laboratory (Gilbert and Martin, 1933; Gilbert, 1934). Since then, many papers and books have described preparations of moist chamber cultures that may differ in methodology but involve wetting field collections of bark from living trees (Keller, 2004; Keller et al., 2004; Everhart et al., 2009; Scarborough et al., 2009; Snell and Keller, 2003), herbaceous plants (Kilgore et al., 2009), and decaying wood or leaves from ground sites, usually at times when myxomycete fruiting bodies are not present (Keller et al., 2008). This technique gives the observer the opportunity to create a self-contained moist environment where the myxomycete plasmodium and developing fruiting body stages are present, although they are not always seen in the field.

Seventh-grade WMS life science students field-collected live tree trunk bark from Eastern Red Cedar trees at Pertle Springs (Figures 4 and 5). This is a short 10-minute bus trip from WMS to a series of trees that line the paved roadway at the entrance of the area (Scarborough et al., 2009). This tree species was targeted because it

has the highest species diversity of life forms, which provided students with the best chance of success observing moist chamber bark cultures (Keller and Braun 1999; Keller and Marshall, 2019; Scarborough et al., 2009; Perry et al., 2020). Two-student team members were briefed on the safe collection of tree trunk bark following instructions on Data Worksheets that recorded species of tree, overall estimated size of the tree (height and diameter; Figure 5), characteristics of bark surface, presence of other life forms (for example, lichens), and height on tree where the bark sample was collected.

Bark samples collected in paper bags were transported to the WMS class laboratory, where students prepared moist chamber cultures in oversized sterile plastic Petri dishes (150 × 25 mm) that were lined with sterile filter paper. About six pieces of bark sample paper covering the bottom of the dish were arranged without overlapping. Thirty mL of sterile deionized water was added around the bark, avoiding directly wetting the bark surface areas. These moist chamber bark cultures were allowed to soak for 24 hours, and any excess water was decanted during the next laboratory period. Observations were made during normal laboratory class sessions twice a week for approximately four weeks. Students recorded pH values using litmus color-coded papers and observed life forms over this period using the naked eye and 20 to 50× power dissecting microscopes (Figures 7–9).

Angela Scarborough (senior undergraduate student, Figure 8) and Courtney Kilgore (master's degree graduate student, Figure 9) from UCM served as mentors for the seventh-grade students, helping them locate and identify life forms in the moist chamber bark cultures. They were also available to answer questions about their tree canopy-climbing experiences in the GSMNP.



**Figure 7.** Two WMS students scan moist chamber bark cultures with dissecting microscope. (Photo by H.W. Keller.)



**Figure 8.** Undergraduate UCM student Angela Scarborough assisting WMS students search for life forms in moist chamber bark culture. (Photo by H.W. Keller.)



**Figure 9.** UCM graduate student Courtney Kilgore scanning moist chamber cultures using a dissecting microscope. Two WMS students on the left, and Harold Keller on the right. Note the red shirts worn by the UCM tree canopy research team highlighting the iridescent myxomycete sporangium *Diachea arboricola*, a tree canopy species new to science. (Photo by T. Smith.)

## MOIST CHAMBER BARK CULTURE HOW-TO VIDEO

In 2021, the first moist chamber culture instructional video, *How to Create a Moist Chamber Culture to View the Biodiversity Growing on Live Tree Bark*, was made available by Ashley Bordelon, Herbarium Digitization Coordinator, of BRIT's Urban Ecology Program. A PDF with accompanying written instructions is also available and can be found at <https://brit.org/research/research-projects/urban-ecology-program/> with the title: *Preparation of Moist Chamber Tree Bark Cultures: A Beginner's Primer for Use at Home* by Ashley Bordelon and Harold W. Keller (Fort Worth Botanic Garden Botanical Research Institute of Texas).

This video emphasizes the moist chamber culture technique using live tree trunk bark samples and store-bought low-cost supplies readily available at local stores for teachers, students, and hobbyists that may want to use this technique. Many teachers cannot afford the more expensive supplies used by the seventh-grade students supplied by an NSF grant-funded activity and the more reproducible protocols required by some publication formats. Nevertheless, this video was created for teachers and community enthusiasts based on live trees in their own backyards or nearby forested areas. Examples of myxomycete fruiting body development are highlighted in this video. This moist chamber technique sometimes results in the discovery of species new to science, as well as rare species seldom or never collected in the field (Keller, 2004; Keller and Marshall, 2019; Perry et al., 2020). This can be an added incentive for beginners to share their discoveries with other myxomycetologists, mycologists, and botanists.

## RESULTS AND OUTREACH ACTIVITIES

Each fall for a four-year period (2004–2007), Keller met with six different seventh-grade life science classes (approximately 120 students) for a total of 18 hours. More than 500 WMS students were involved in this teaching activity over the course of 90 hours. On September 28 and 29, 2004, six groups of 20 WMS students were transported to Pertle Springs for one-hour field trips to collect trunk bark samples from living trees. During much of this time, Angela Scarborough and Courtney Kilgore also assisted students (Figures 8 and 9).

These activities were presented in popular media such as newspapers, television, websites, and exhibits. For example, UCM highlighted our research with a color image and short storyline on the front page of the university website. *The Daily Star Journal* ran two color images under the banner headline featuring Local Nature Lesson, that described the seventh-grade life science students collecting activities at Pertle Springs, and another front-page article titled *Junior Scientists at Work*, showing a color photograph of students and Dr. Keller observing moist chamber cultures with a description of the RET-NSF Program.

Local interest in this RET-NSF funded project was noted in *UCM News* under the title *Grant Provides Experience in Scientific Research*. Campus Today featured Trish Smith collecting bark samples, and another article *More Than a Bug's Life Fascinates*, showed students collecting insects using flight intercept canopy traps at Pertle Springs. Television station KMOS, housed at UCM, sent film crews to shoot footage of WMS students at Pertle Springs that aired as a five-minute segment on *University Magazine*. The RET-NSF

poster (Keller et al., 2005) presented at the Fifth International Congress on Systematics and Ecology of Myxomycetes (ICSEM5) in Tlaxcala, Mexico, was displayed at WMS and also at the UCM Morris Science Building.

One striking example of student observations was the surprise discovery of nematodes. These attention-getting nematodes, with their S-shaped wiggling and writhing movements in thin films of water, were frequently observed by students in moist chamber cultures from bark of living trees. Nematodes in some bark cultures were attached by their posterior ends, standing and waving in a behavioral pattern known as nictation. Nematode movements were also observed in the video of moist chamber bark cultures highlighted here by Ashley Bordelon.

Our efforts to involve seventh-grade students in the research objectives of this project was to transfer knowledge about how biodiversity is documented to the next generation of students. Websites and posters also disseminated field biology to a broader audience of students and teachers alike (Figure 10).

## CONCLUSIONS

“Teaching has been an extremely rewarding job in many ways, but bringing the GSMNP research project into my seventh-grade life science classroom through the RET Program is one of my proudest moments,” Trish Smith said. The highest tribute or reward Keller could ever receive is the twinkle in the eyes and glow and smile on the faces of the seventh-grade life science students at WMS when they said that “it’s awesome” or “it’s cool” after observing a myxomycete sporangium or plasmodium. These students learned to picture key and recognize different myxomycete species, insect taxa, and general life forms of lichens, mostly crustose and foliose types. The aim of this activity was to assist and encourage students and teachers to experience field trips and laboratory exercises that will create excitement and interest in exploring, collecting, and discovering life forms often overlooked in nature.



**Figure 10.** Tree canopy research team in GSMNP. Far left, Stan and Trish Smith; UCM undergraduate students Amber, Tommy, Ashley back row, bottom row Erin and Cheryl; far right, Steve Wilson. (Photo by H.W. Keller.)

## ACKNOWLEDGMENTS

Special thanks go to Trish Smith, who was responsible for preparing the iAdventure, Teacher Preparation Guide, Student Worksheets, and logistics for the student field experience at Pertle Springs and laboratory observations. Without her and Stan's help, this activity would not have been possible. Ashley Bordelon used her creative talents to brainstorm the video content, organize the visual images, and narrate the moist chamber instructions. Dr. Joe Ely, ecologist and biometrician, and Dr. Steve Wilson, entomologist from UCM, were essential co-investigators on this research project. Charly Pottorff, a professional arborist, taught UCM students the double rope climbing method and how to shoot the Big Shot at a climbing school at Pertle Springs. Many people contributed their volunteer expertise and we thank them all, including parents, faculty from the UCM Biology and Education Departments, the UCM student mentors and tree climbers, and investigators from other institutions. This student activity would not have been possible without the help of many people not named but who contributed time, effort, cooperation, and authorship on publications. Multiple grants provided financial assistance in part from the National Science Foundation, Discover Life in America, National Geographic Society, Sigma Xi, The Scientific Research Honor Society, Missouri Department of Natural Resources, the U.S. Department of Education McNair Scholars Program, and the UCM Summer Undergraduate Research and Creative Projects Program. Photographic credits are given after each photograph, and image release forms were obtained from all WMS students. We trust that this spirit of discovery described here will lead others to explore, enjoy, learn, and share their results with others.

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# Filling in the Gaps: Targeted Plant Collection by Undergraduates and Citizen Scientists to Better Understand Plant Distribution

## Abstract

Research experiences benefit undergraduates and citizen scientists alike, and new resources allow for new research opportunities. With the expansion of online databases, current understanding of plant distributions is better than it has ever been. Database resources also show gaps in species distribution and allow rapid identification of areas that are under-collected. Targeted collecting of common but often overlooked plant species is an excellent way to engage undergraduates and citizen scientists. Here we provide an example of targeted plant collecting by undergraduates that resulted in 118 collections made over four days in Ouray County, Colorado. These collections resulted in 34 new country records not listed in the Flora of Colorado and 15 new county records not listed on SEINet.

Course-based Undergraduate Research Experiences (CUREs) and outreach to the public through citizen-science projects have become increasingly common (AAAS, 2011; Dolan, 2016). Applications like iNaturalist have millions of users around the globe, showing that there is a strong interest in participating in science (iNaturalist.org). Research can help form beneficial collaborations between amateurs and professionals, increase scientific communication and engagement, and help prepare the next generation of scientists. In the botanical sciences, a variety of methods has been used to engage high school students (Ragostra et al., 2020), undergraduates (Ward et al., 2014; Mitchell et al., 2017), and citizen scientists (Boho et al., 2020).

## Key words

citizen science, Colorado, flora, species distribution, undergraduate



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## MATERIALS AND METHODS

One area ripe for research by amateurs is utilizing online database resources. Online databases, such as SEINet ([www.swbiodiversity.org](http://www.swbiodiversity.org)) and the USDA PLANTS database (<https://plants.sc.egov.usda.gov/java/>), as well as traditional floras, allow unprecedented access to plant distributions. Mapping tools on online databases allow users to rapidly assess plant distributions and visualize areas that are likely habitat for plant species but currently do not have specimen records. Impetus for this study began with observation of distribution maps in the Flora of Colorado (Ackerfield, 2015) where it was noted that Ouray County was often a gap in species distribution maps. Further investigation using online databases showed that although Ouray County has been moderately well collected compared to other areas in western Colorado, many common species have not been collected in this county.

Targeted collecting not only increases understanding of species distribution, but also benefits amateur botanists. While many scientists use online databases, these resources are often unknown or underutilized by the general public. Training amateur botanists to use online resources and technical keys, to plan and implement a plant collecting trip, and to process and curate specimens in the herbarium, broadens interest in botany and trains the next generation of botanists. Not only are valuable data collected and made available to scientists via databases such as SEINet, but these studies also help to form collaborations between scientists and plant enthusiasts. The goals of this study were to (1) collect specimens to fill in the gaps of species distribution in Ouray County, Colorado, (2) engage undergraduates in plant collecting, and (3) provide a model for other scientists working with undergraduate or citizen scientists.

This study was conducted as part of a summer undergraduate research project led by Dr. Stephen Stern supervising undergraduate students Nora Oviatt and Grace Gardner. All aspects of the project were performed by the two undergraduate students. To become more familiar with the area prior to collecting, the Flora of Colorado (Ackerfield, 2015) was used to compile a list of plants that had not previously been collected in Ouray County. Emphasis was given to plants that were present in two or more neighboring counties on maps in the Flora and therefore likely to be present in Ouray County. The list included plant family, common name, scientific name, elevation range, and flowering time. This list was then used to identify collecting sites, including a wide range of habitats and elevations, to maximize species diversity. Collection sites included pinyon-juniper forests, subalpine meadows, riparian areas, parking lots, and other disturbed areas to include common and invasive species (Figure 1).

Collections were made in Ouray County, Colorado on July 14-17, 2020 by Nora Oviatt and Grace Gardner, two undergraduates at Colorado Mesa University in Grand Junction, Colorado. Areas collected included a variety of habitats, elevation ranges, and moisture gradients (Figure 2). Plants were collected if they were known to be missing from Ouray County or if their identity was unknown. Plant specimens were pressed and locality information including GPS coordinates and elevation was collected, along with habitat and plant characteristic data.

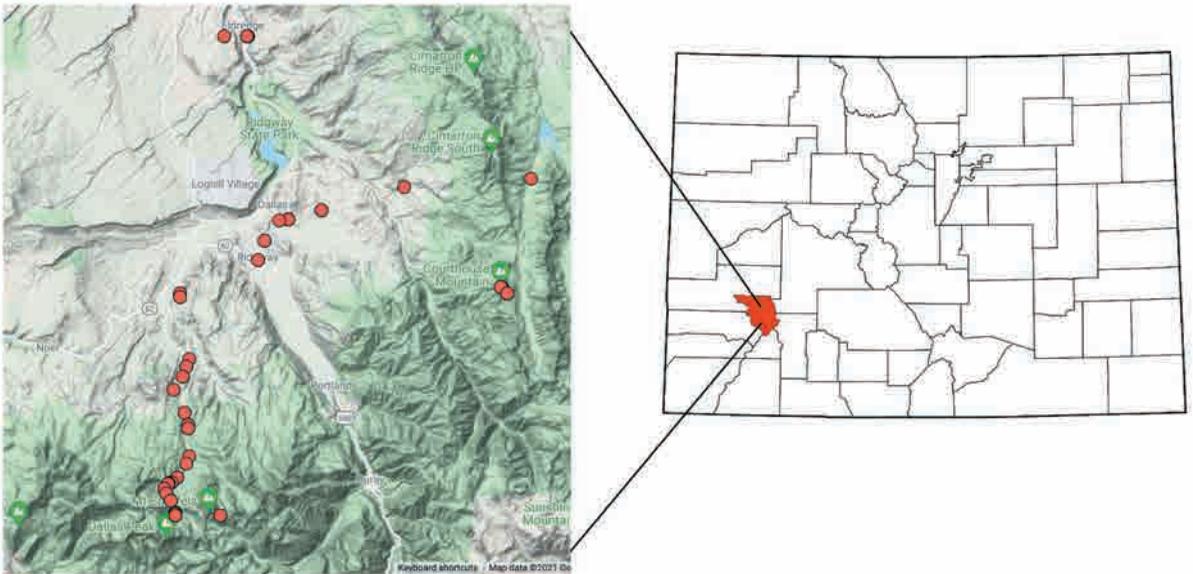


**Figure 1.** *Diversity of Habitats in Ouray County. (A) Nora Oviatt by the Uncompahgre River. (B) Top of Courthouse Mountain. (C) Nora Oviatt in meadow by lower Blue Lake. (D) Pinyon-Juniper habitat at the Ridgeway Area Trails. (E) Grace Gardner collecting in roadside habitat along Ouray County Road 10. (F) Grace Gardner on Courthouse Mountain Trail.*

After collecting, the undergraduates identified unknown plants using the Flora of Colorado (Ackerfield, 2015). Plant specimens were mounted onto herbarium paper with a label including all specimen data and deposited in the Walter A. Kelley Herbarium at Colorado Mesa University. Specimen data were entered in the Intermountain Region Herbarium Network database (<https://intermountainbiota.org/portal/>). Collections were compared with distribution maps in the Flora of Colorado (Ackerfield, 2015) and SEINet (<https://intermountainbiota.org/portal/>) to identify collections that were new county records.

## RESULTS

Over the course of four days of collecting in Ouray County, 118 collections representing 99 species were made from a variety of localities and habitats (Figures 1 and 2). These species represent both native and introduced, naturalized species. The goal of this project was to provide herbarium specimens to increase understanding of plant distribution. Herbarium specimens collected for this project represent 34 new county records for Ouray County (Table 1) when compared to distribution maps in the Flora of Colorado (Ackerfield, 2015). Collections



**Figure 2.** Map of Colorado with Ouray County highlighted in red (right) with zoomed in map of Ouray County including the towns of Ridgeway and Ouray showing collection sites (left). Red points represent collections sites. Between 1 and 31 collections were made at each site.

were also compared with SEINet (<https://intermountainbiota.org/portal/>), a regularly updated database. Based on SEINet search results in July 2021, the collections made in this study represent 15 new county records for Ouray County, Colorado (Table 1).

## DISCUSSION

While much of the flora of the United States is well-represented in herbaria, there are significant gaps in understanding species distributions. As the results show, a four-day collecting trip by two undergraduates yielded numerous new county records, indicating that this research is beneficial in building knowledge of species distributions. The discrepancy in the number of new records when comparing the distribution maps in the Flora of Colorado versus SEINet can be attributed to the fact that SEINet is continually being updated. Databasing projects, such as

the NSF-funded databasing project focused on plants of the Southern Rockies (<https://www.soroherbaria.org/portal/>; Tripp et al., 2017), have added many new records since the publication of the Flora of Colorado. Despite this influx of new databased records, many areas still lack sufficient representation by herbarium specimens.

Of the 118 collections, 34 represented new county records based on the Flora of Colorado and 18 represented new county records based on SEINet (Table 1). In Ouray County, some species were expected, such as *Convolvulus arvensis* (field bindweed) that is represented in all surrounding counties but was lacking in Ouray County in the Flora of Colorado distribution maps. *Centaurea stoebe* (spotted knapweed) is listed as a class B noxious weed in Ouray County (<https://ouraycountycogov/155/Weed-Control>) but had not previously been collected and was not represented on SEINet or in the Flora of

**Table 1.** List of collections from Ouray County that represent new county records for the Flora of Colorado (Ackerfield, 2015) and SEINet.

Family	Scientific Name	Common name	New to Ackerfield?	New to SEINet?	Collection number
Amaranthaceae	<i>Atriplex canescens</i> (Pursh.) Nutt.	Four-wing Saltbush	yes		N. Oviatt 73
Apiaceae	<i>Angelica pinnata</i> S. Watson	Small-wing Angelica	yes	yes	G. Gardner 129
Apocynaceae	<i>Asclepias speciosa</i> Torr.	Showy Milkweed	yes	yes	G. Gardner 171
Asteraceae	<i>Carduus nutans</i> L.	Musk Thistle	yes		G. Gardner 173; N. Oviatt 102
Asteraceae	<i>Centaurea stoebe</i> subsp. <i>micranthos</i> (S.G.Gmelin ex. Gugler) Hayek	Spotted Knapweed	yes		N. Oviatt 77
Asteraceae	<i>Cichorium intybus</i> L.	Common Chicory	yes	yes	G. Gardner 179
Asteraceae	<i>Erigeron philadelphicus</i> var. <i>philadelphicus</i> L.	Philadelphia Fleabane	yes	yes	G. Gardner 112
Asteraceae	<i>Helianthus annuus</i> L.	Common Sunflower	yes		G. Gardner 147
Asteraceae	<i>Lactuca serriola</i> L.	Prickly Lettuce	yes	yes	G. Gardner 168
Asteraceae	<i>Solidago nemoralis</i> subsp. <i>decemflora</i> (DC.) Brammall ex Semple	Gray Goldenrod	yes	yes	N. Oviatt 108
Asteraceae	<i>Symphotrichum ciliatum</i> (Ledeb.) G.L. Nesom	Rayless Alkali Aster	yes	yes	G. Gardner 175
Asteraceae	<i>Tetradymia canescens</i> DC	Common Horsebrush	yes	yes	G. Gardner 111
Convolvulaceae	<i>Convolvulus arvensis</i> L.	Field Bindweed	yes		N. Oviatt 75
Cyperaceae	<i>Carex raynoldsii</i> Dewey	Raynold's Sedge	yes	yes	N. Oviatt 113
Cyperaceae	<i>Scirpus validus</i> Vahl	Softstem Bulrush	yes	yes	G. Gardner 115

Fabaceae	<i>Astragalus cicer</i> L.	Chickpea Milkvetch	yes	G. Gardner 170
Fabaceae	<i>Medicago sativa</i> L.	Alfalfa	yes	G. Gardner 117
Fabaceae	<i>Melilotus alba</i> Medik.	White Sweet Clover	yes	G. Gardner 113
Fabaceae	<i>Trifolium pratense</i> L.	Red Clover	yes	G. Gardner 139
Geraniaceae	<i>Erodium cicutarium</i> (L.) L'Her. ex Ait.	Filaria	yes	G. Gardner 109
Malvaceae	<i>Sidalcea neomexicana</i> A. Gray	Rocky Mountain Checker-Bloom	yes	G. Gardner 142; N. Oviatt 78
Nyctaginaceae	<i>Mirabilis linearis</i> (Pursh) Heimerl	Narrowleaf Four O'Clock	yes	G. Gardner 177
Onagraceae	<i>Chamerion latifolium</i> (L.) Holub	Dwarf Fireweed	yes	N. Oviatt 91
Onagraceae	<i>Epilobium hornemannii</i> Rchb.	Hornemann's Willow-herb	yes	N. Oviatt 114
Orobanchaceae	<i>Pedicularis procera</i> A. Gray	Giant Lousewort	yes	N. Oviatt 88
Phrymaceae	<i>Mimulus tillingii</i> Regel	Subalpine Monkey-Flower	yes	N. Oviatt 117
Plantaginaceae	<i>Plantago tweedyi</i> A. Gray	Tweedy's Plantain	yes	G. Gardner 116
Poaceae	<i>Agropyron cristatum</i> (L.) Gaertn.	Crested Wheatgrass	yes	G. Gardner 148
Polygonaceae	<i>Eriogonum microtheca</i> var. <i>laxiflorum</i> Hook.	Slender Buckwheat	yes	G. Gardner 110
Rosaceae	<i>Crataegus succulenta</i> Schrad.	Rocky Mountain Hawthorn	yes	N. Oviatt 81
Rosaceae	<i>Potentilla plattensis</i> Nutt.	Platte River Cinquefoil	yes	G. Gardner 130
Rosaceae	<i>Sanguisorba minor</i> Scop.	Garden Burnet	yes	G. Gardner 176
Salicaceae	<i>Populus deltoides</i> W. Bartram ex Marshall	Cottonwood	yes	G. Gardner 172
Typhaceae	<i>Typha latifolia</i> L.	Broadleaf Cattail	yes	N. Oviatt 79

Colorado. This work also expanded the known range of species, such as *Mimulus tillingii* (subalpine monkeyflower) and documented previously unknown populations.

This study focused on an under-collected area of western Colorado. Ouray County (542 mi<sup>2</sup>) is represented on SEINet by 6885 collections. Many other significant gaps remain in the Flora of Colorado. For example, in northeastern Colorado, Sedgwick County (549 mi<sup>2</sup>) has 913 collections on SEINet, Phillips County (688 mi<sup>2</sup>) has 628 collections on SEINet, and Crowley County (800 mi<sup>2</sup>) has 459 collections on SEINet. Similar collection projects in these counties would add many new species records to SEINet and the Flora of Colorado. In Colorado, it appears that areas further from population centers and universities generally have fewer plant collections. However, even urban areas can be under-collected, such as Broomfield County (33 mi<sup>2</sup>), which only has 12 collection records on SEINet. This trend is likely similar in other areas, and mapping tools on sites like SEINet or the USDA PLANTS database can provide localities for similar projects in other states.

In addition to increasing scientific understanding, this research is a useful teaching tool for undergraduates and citizen scientists. The planning, collection, and specimen preparation described above was led by undergraduates. Students had to plan an “expedition,” determine logistics, research distributions using databases, collect plants in the field, identify plants, prepare specimens, and database specimens. While there was guidance from a professor, the implementation of all aspects was done independently by students. Although this project was a trail run, occurred outside of a class, and only included two undergraduates, all of the components of the project could easily be incorporated into

a plant identification or plant systematics course and would make an excellent CURE. This could also be implemented as a project for native plant enthusiasts where interested participants have many of the skills but may not know how they can contribute to the scientific community. The Colorado Native Plant Society (CONPS.org) frequently has “bioblitz” events, but independent, guided collecting in targeted areas would allow enthusiasts to conduct investigations on their own schedule, would allow more flexibility, and would encourage revisiting sites to collect plants throughout the growing season.

While targeted collecting can be largely independent, there are some logistics that require oversight. The undergraduates involved in the project were well-versed in plant identification and collecting methods but found the planning and implementation of their own collecting trip to be the most difficult, but also most rewarding, aspect of the project. For supervisors, knowing the abilities of students and adjusting the level of supervision accordingly is crucial. For example, some students may have more difficulty with plant identification and need additional help in this area. This study only included two undergraduates, so as the group size increases there would likely be more challenges managing larger cohorts. However, this also provides a great opportunity for group work. Collecting must follow state and federal restrictions, with care taken to avoid private property, protected areas, and protected plants. Arrangements should be made for herbaria to receive specimens, and there should be oversight during the databasing process. In lieu of making collections, amateur botanists could make observations along with photographic evidence (as is done with the iNaturalist app). While this reduces specimen preparation, it presents challenges for correct identification and makes verification much

more difficult. With either collections or observations, amateur botanists may need assistance identifying difficult taxa. Each of these steps requires oversight but can be “teachable moments” to help train the next generation of botanists. Coupling the passion and enthusiasm of amateur botanists with the oversight and guidance of professional can greatly benefit both.

## ACKNOWLEDGMENTS

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## AUTHOR CONTRIBUTIONS

Dr. Stephen Stern supervised the planning and implementation of this research and prepared the manuscript. Undergraduates Nora Oviatt and Grace Gardner conducted fieldwork, identified and prepared plant specimens, databased specimens, and reviewed the manuscript.

## DATA AVAILABILITY

All specimen data are available online through the SEINet portal at [intermountainbiota.org](http://intermountainbiota.org).

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# The Future of Botany: Educating for a Diverse and Inclusive 21st-Century Workforce

The National Science Foundation–funded conference grant “The Future of Botany: Educating for a Diverse and Inclusive 21st Century Workforce” (NSFDBI-1929435, \$64K, Adams & Krakos, 2019–2021) has ended after supporting three years of Botany conference activities related to strategic efforts to broaden participation and teach inclusively. Originally a single-year award, BSA received a no-cost extension to continue to provide support for activities and participation by community college/tribal college and university (CC/TCU) faculty and undergraduates at the 2020 and 2021 virtual Botany conferences. The project had three main goals:

1. To support CC/TCU faculty to attend and participate in the Botany conference to help more effectively recruit, retain, and support a diverse and inclusive next generation of plant scientists
2. To support additional undergraduate students primarily from CC/TCU institutions to attend and participate in the Botany conference as part of the existing PLANTS mentoring program for students from underrepresented minority groups.
3. To develop, deliver, and promote diversity and inclusion programming at the Botany conference for all attendees.

The grant supported a coordinated Diversity and Inclusion (D&I) initiative starting at Botany 2019 by integrating several new sponsored activities with ongoing DEI and Education activities (including the NSF-supported PLANTS Botany conference mentoring program and programming developed by the BSA’s DEI committee, Education Committee and Teaching Section). The co-PIs, Catrina Adams and Kyra Krakos, worked with an advisory board including Ann Sakai, Muriel Poston, Mike Barker, Jim Cohen, Chris Martine, and Anna Monfils to create a set of activities centered around D&I needs of Botany, and to recruit participating speakers, students, and faculty.

This article is a summary of the activities and impact of the grant, enhanced with personal experiences and insights shared by five co-authors: Matt Haberkorn (Phoenix College, AZ); Adolfina Koroch (Borough of Manhattan Community College, NY); Sonali Saha (Miami Dade College, FL); Karen Wellner (Chandler-Gilbert Community College, AZ); and Daniel Wright (Pima Community College, AZ), who were faculty participants in the initiative over several years.

**By Kyra N. Krakos, Catrina Adams, Matt Haberkorn, Adolfina Koroch,  
Sonali Saha, Karen Wellner, and Daniel Wright**

## DIVERSITY AND INCLUSION INITIATIVE BEGINS AT BOTANY 2019 IN TUCSON, ARIZONA

The grant sponsored some new programming at Botany 2019 in Tucson, AZ open to all conference attendees including:

1. A Special Session titled “Educating for a Diverse and Inclusive Community in Botany for the 21st Century,” featuring talks by invited speakers Teresa Newberry (“The Role of Tribal Colleges in Promoting a Diverse and Inclusive Community in Botany”), Anthony DePass (“Increasing Diversity in STEM: Bridging Practice and Scholarship”), Monica Gaughan (“The Ecological Fallacy and Why Botanists Still Need to Understand Student Demographics”), and Pamela Soltis (“Engaging a Diverse Biodiversity Workforce through Natural History Collections”), and including a moderated discussion between the audience and speakers;
2. A workshop on inquiry-based learning in plant science led by Gordon Uno and Marsh Sundberg, with an emphasis on exchanging best practices and ideas on methods for engaging students with diverse backgrounds in learning science using plants; and
3. A special contributed paper section in the Teaching Section with a specific emphasis on inclusive pedagogical practices in various institutional settings. All of these activities took place at Botany 2019 meetings in Tucson, AZ.

In 2019, the grant was able to support 13 CC/TCU faculty to attend Botany and participate in the Initiative’s activities. In

addition to attending the activities open to all Botany attendees, participants attended an orientation/meet-and-greet to allow others from the BSA community to welcome and get to know the grant participants, as well as to introduce the conference activities and answer any questions. The participants also attended a working dinner to process and discuss what they’d learned and to discuss options for continued participation and networking beyond the Botany conference.

Post-conference, CC/TCU faculty participants were asked to respond to a prompt about what they gained from participating in the conference. New perspectives on teaching were mentioned by several faculty. Several faculty mentioned that the workshop led by Uno and Sundberg was a highlight for them. One wrote, “The workshop on broadening pathways changed my whole perspective on teaching, so now I focus on making my classes more equitable, not just inclusive, understanding that students all start in different places.” Another responded, “The 2019 Botany meeting provided me with a significant amount of teaching processes, activities as well as accessible research questions that can be covered in a typical community college class...as a result, we have seen students interest and engagement increase in some of our course-based research programs...I attribute this to making research-based course projects accessible, understandable, and multidisciplinary for our students.” A third contributed an anecdote about how a workshop activity sparked a redesign of a food web activity for students that led to a highlighted activity during a “Free College for a Day” event showcasing learning highlights for prospective students.

The grant also supported eight additional undergraduates from underrepresented minority groups to participate in the longstanding PLANTS mentoring program (supported by NSF DEB-1137471, \$100K, Sakai & Hirsch 2011-2016 and NSF DEB-1549708, \$106K, Sakai & Monfils 2015-2021) as PLANTS Scholars in 2019, along with four PLANTS alumni recruited to serve as near-peer mentors for these students. The PLANTS student experience kicked off with an early morning meeting for past and current PLANTS Scholars, followed by field trips and a workshop on Applying to Graduate School led by PLANTS co-PI Anna Monfils and a career panel discussion. A meeting of PLANTS Scholars with their peer and senior mentors followed. Scholars and Mentors were provided with materials to facilitate meaningful interactions and information exchange, including some suggested questions to seed the conversation. Throughout the Botany conference, each group consisting of the Scholar and Mentors met daily to organize activities, plan to attend specific talks together, and discuss talks post-attendance. Scholars attended the Diversity Luncheon, which in 2019 was led by Tom Antonio from the Institute of American Indian Arts. A final working lunch was held the last day for a meeting wrap-up and review of the program.

## FUNDED INITIATIVE EVENTS & PARTICIPANT REGISTRATION WERE EXTENDED THROUGH BOTANY 2020 & 2021 VIRTUAL CONFERENCES

In response to the Covid-19 pandemic, Botany 2020 and 2021 moved to a virtual platform. We applied for and received a no-cost extension from NSF in order to continue the Diversity and Inclusion Initiative, to build on the positive outcomes of the first year, and to ensure that the new networks among CC/TCU faculty being built would be retained. The virtual format provided a unique opportunity to expand the reach of the initiative. In the virtual years, the remaining funding could go further in extending participant support. The extended grant provided registration funds for seven of the previous faculty grant awardees to return to the conference with preference given to those who would be presenting a paper or poster. In addition, four of the undergraduate PLANTS students were funded to return and participate in some of the PLANTS activities with the 2020 cohort to share their experiences, although they did not receive faculty and peer mentoring for a second year.

Programming at the Botany 2020 conference organized and promoted as part of this grant's Diversity and Inclusion Initiative and open to all attendees included a workshop "Teaching Online Botany Laboratory for Non-Majors," a themed paper session "Education and Outreach III: Diversity and Inclusion in Botany," and a roundtable discussion "Creating an Inclusive Experience in the Classroom and Across the Discipline of Botany: Perspectives from Community

College Faculty.” Additional conference-wide D&I programming recommended to participants included a “Diversity, Equity and Inclusion Listening and Discussion Session,” the Diversity in Plant Biology Special Session “Diversity and Inclusion in the Sciences: Relationships and Reciprocity” given by Beth Leonard, University of Alaska Anchorage, and the plenary address “What Have We Learned? Lessons and strategies from the Chaos” by Brian Dewsbury, University of Rhode Island.

In 2021, five of the existing faculty cohort were funded to return and we also were able to offer participation to seven new faculty participants drawn from CC/TCU and other minority serving institutions (MSIs). Faculty who were accepted to participate were invited to bring up to 5 of their undergraduate students to attend the conference, and 18 undergraduate students took advantage of the offer to participate with their faculty.

Initiative events open to all attendees followed the same pattern as in 2020, including a workshop “Challenges and Successes of Research at Primarily Undergraduate Institutions: Jumpstarting Your 2021-2022 Research Program,” a themed paper session “Education and Outreach I: Botany for Diverse Audiences and Under-Resourced Communities,” and a roundtable discussion, “Educating for a Diverse and Inclusive Community in Botany for the 21st Century.” Additional D&I conference programming recommended to participants included the Belonging in Botany: Perspectives on DEI Lecture “Race and Science: from Collectors to Allies” given by David Asai, Howard Hughes Medical Institute, and the plenary address “From Seeds of Change to a Harvest of Discovery” by Beronda Montgomery, Michigan State University.

In 2021, the roundtable discussion was particularly robust, with participants sharing their best practices and solutions to challenges. Key points included the importance of paying attention to climate in the classroom for greater inclusivity, being mindful of student group work norms and group composition, and establishing student cohorts through intentional activities designed to increase a sense of belonging and community. Encouraging research at the undergraduate level including CURES and modeling best practices of collaborative science during research was also mentioned. Challenges included a lack of botany research opportunities for interested undergraduate students compared to in the medical field or biotechnology (or a lack of awareness of these opportunities by CC/TCU faculty), increasing pressure to closely tie course offerings at community colleges to available jobs on graduation and the decreasing prevalence of botany course availability as well as increased need to “market” the importance of plant science classes to students and administrators. Several faculty mentioned how useful it is or could be to have connections with faculty at nearby 4-year institutions who could support transferring CC students interested in botany careers, and suggested this as a place where BSA may be able to help. Many participants mentioned the lack of time, mental resources, or funds available to CC faculty and other faculty who work with diverse student populations, as well as often feeling disconnected from peers and lacking support from peers in their discipline(s). A helpful wish list of future possible workshops was proposed by participants, including interactive activities to implement in the classroom (as was offered by D&I in 2019), a repeat of the Online Botany Laboratory workshop (offered by D&I in 2021), as well

as new ideas for workshops similar to those offered by the University of British Columbia's Kindness Project, workshops focusing on new technologies for classroom and research in undergraduate institutions, as well as workshops on gender identity and pronouns and on traditional ecological knowledge. Final thoughts on making use of exemplary programs and models from other disciplines were also shared along with existing resources that participants had found useful or interesting. Some excellent ideas on how to support each other were shared: "We talk about the importance of cohorts for our students...what about for ourselves?" The discussion of this need led to plans for implementing a kind of virtual support system to extend connections beyond the Botany conference. Part of these plans may be fulfilled through the Teaching Section and Education Committee's plans to schedule year-round events as part of BSA's new Botany360 initiative.

## IMPACT OF THE PROGRAM

The coordinated emphasis on D&I throughout the Botany 2019, 2020, and 2021 conferences, including activities associated with this Diversity and Inclusion Initiative (pedagogy workshops, targeted contributed paper sessions on teaching with equity and inclusion, roundtable discussions including D&I participating faculty), is an important way to share pedagogical knowledge, scientific knowledge, and culturally sensitive practices in the plant sciences across the BSA and Botany conference communities. These combined activities were intended to stimulate members and conference participants to think strategically about how to broaden participation and to be more inclusive in how they teach and work. The project also enabled

both faculty and students from under-resourced groups to attend Botany, with an opportunity to promote the development of a set of best practices to support outreach and mentoring of diverse students in the plant sciences.

PLANTS Scholars supported by this grant were able to experience the excitement of basic research, gain greater appreciation of the critical importance and application of the botanical sciences in their lives, and understand the job opportunities in these areas, thus broadening their career options. By supporting additional students to participate in the longstanding PLANTS mentoring program, we were able to introduce more students who are making critical decisions about their careers to the breadth of disciplines within plant sciences. Including CC and TCU students meant including PLANTS Scholars who are earlier in their undergraduate careers than typically accepted. These students have more time to use what they learn from the Botany experience and their mentors to consider whether graduate school is something they'd like to pursue as part of their career pathways. This can lead them to make more informed choices as an undergraduate to better prepare them for whatever career pathway they choose.

Feedback and evaluation surveys for PLANTS Scholars are anonymous, so it's not possible to pull out responses of the eight Scholars specifically sponsored by this grant. However, feedback from the Scholars as a whole speaks to the impact of the program for these students. The most common response to the question about the best part of the program was the mentors, and some students were especially appreciative that their two mentors could offer different perspectives to them. Some notable

quotes from the free-response questions included: “This conference has shown me HOW COOL plants are and the many ways you can study them.” “This program affirmed my dedication to plant science: It was a wonderful diverse community which was welcoming and kind and encouraging; I am glad to be a part of it and continue to be a part of it.” This idea of feeling welcome occurred in other quotes, for example: “going into BOTANY 2019 I felt lost and like I didn’t really have a place within the scientific community...The PLANTS program made me feel like I do have a place or at least can make a place for myself. It made me realize that I want to pursue a PhD and push myself to achieve my goals.”

Techniques for engaging students from underrepresented minority groups, for adapting to online teaching during the pandemic, and for training students in critical thinking, data literacy, and other science skills covered during the meeting will translate beyond botany to other classes participating faculty will teach. The focus on techniques for engaging non-majors with plant science is likely to impact many students who do not intend to focus their future careers on botany, but will go on to pursue other disciplines in and outside of STEM and will benefit from an introduction to the importance of plants and science in their everyday lives as well as practical experience with scientific thinking and making sense of data.

Many faculty participants mentioned how useful they found the programming. One wrote, “Everything I’ve participated in has been helpful to me and my students. I’ve learned lots of new ideas and techniques to use in my classes, and my students have benefited from participating in the scientific community as peers.” Another participant shared, “Honestly,

I reached another level in terms of initiating class-based activities, research projects, service hours opportunities that enable students to learn about different aspects of plants: how they grow, structure-function relationships and the services they provide.” A third wrote, “...I think I was able to come up with more spontaneous critical questions after attending the teaching workshops. Students enjoyed those dynamic conversations.” As one faculty participant stated, “The initiative provides a gateway to establish oneself as an educator who can influence students’ lives and careers in multiple ways.” Another mentioned his own growth in knowledge about plant sciences, “I was able to interact with scientists and educators who really desire to work with undergraduates. My biggest benefit was to see the very broad research in botany. As a non-botanist myself, I was just amazed at the types of research and I know that my students would be too.”

Several participant co-authors have shared specific contributions to plant science education they’ve been able to make inspired by their participation in this initiative. Karen Wellner (Chandler-Gilbert Community College, AZ) credits the program for inspiring her to contribute to the Plant Science Bulletin (“Botany with Spirit: Cornell Rural School Leaflets and Gardening”) and to develop a teaching project based on the Saguaro cactus on her campus that she presented at the BSA co-sponsored Life Discovery – Doing Science Education conference held in Estes Park, Colorado in October 2021. Sonali Saha (Miami Dade College, FL) writes: “The decline in community college enrollment across the United States has worsened since the pandemic. Faculty scrambled to restructure and make their content accessible online and help with college retention and enrollment. Any

implementation of innovative programming, techniques, and research initiatives had to be cast aside to cater to more basic needs such as availability of laptops. Amidst these challenging times, the workshops, roundtable discussions and focus groups organized by the Diversity and Inclusion Initiative, and the listening ear provided by the initiative were extraordinarily significant in boosting enthusiasm. It honestly catapulted me into implementing innovation. I opened a small field laboratory at the premises of our college arboretum with a grant I received and with additional funding from the college so the students could be outdoors and continue to get learning and research experiences in botany. In this short time, ‘Viva Florida Garden and Laboratory’ has been a success beyond our imagination: enhancing student participation, learning, and fostering student research.”

## THE PROGRAM'S LEGACY AS PART OF THE NEW BOTANY AND BEYOND GRANT

Many of the activities of this initiative will continue as part of the BSA's newly awarded “Preparing Leaders and Nurturing Tomorrow's Scientists: Botany and Beyond (PLANTS III)” grant (NSF DEB-2138730, \$1.25M, Monfils, Poston & Adams, 2021–2026). The overall goals of Botany and Beyond are to engage, support, and sustain a diverse community of emerging scientists, foster inclusive practices across the BSA and botanical sciences, increase plant awareness, and advance research and training for a more diverse, inclusive, and accessible 21st-century botanical science workforce. The new grant will take a three-pronged approach to achieving these goals. The Botany and

Beyond grant includes funding to continue the successful PLANTS pathway program that provides mentoring and career support to historically excluded undergraduate students (PLANTS III) attending the annual Botany conference. Along with continued updates, assessment, and new support programming for PLANTS, the Botany and Beyond funding will support CC/TCU/MSI faculty travel, professional development and engagement at Botany meetings in ways that build on the work and outcomes of this D&I initiative. The Botany and Beyond grant will also support a new initiative to provide opportunities for early degree students and their faculty to explore botany and other biodiversity careers through an annual place-based science identity workshop held prior to each year's Botany meeting in the region of the upcoming conference. These hands-on workshop experiences will expose the students and faculty to careers, opportunities, and resources spanning the breadth of botanical and biodiversity careers.

## GROWING A MORE INCLUSIVE SOCIETY BY SUPPORTING CC/TCU/MSI FACULTY AND STUDENTS IN BSA LEADERSHIP

Faculty from CC/TCU/MSI who were supported to attend reported feeling more connected to the larger botany community, finding support from peers and new resources to take back to their own institutions. Several participants have volunteered for leadership roles in the BSA (Charles Bush: undergraduate student representative, BSA Diversity, Equity

and Inclusion Committee; Karen Wellner, member BSA Education Committee; Sean Whitcomb, member Advisory Committee, Botany and Beyond grant), enabling their important perspectives to shape the future of the Society and Society initiatives. As one focus group participant stated, “I’ve always been a passive member of scientific societies, but I feel much more motivated and encouraged to get involved in BSA because of the work you’ve done.”

Science will not thrive unless it is equally accessible to students from all backgrounds, including those from groups that are historically excluded. Access involves knowledge about the discipline, understanding the culture of science, feeling welcome as a participant in scientific endeavors and as a member of the scientific community, and understanding job opportunities in the area. This program directly encourages URM students to become part of the scientific community. The faculty professional development offered by this project and inclusion of CC/TCU faculty in the Botany conference ensure that faculty who instruct URM students can do so using best practices for supporting outreach and mentoring of diverse students in the plant sciences, and that faculty from CC/TCU who might otherwise feel isolated from the botanical research community are resourced to participate fully and to make connections within that community. A participant wrote, “Personally, the biggest benefit to me was connecting and networking with the members, and learning of resources and opportunities to teach and foster interest in plants to a diverse audience attending a community college.” Another spoke to the welcoming nature of the conference: “It is a great opportunity to grow, to meet new colleagues, to network, to get and

share ideas and possible collaborations. The environment is welcoming and dynamic.”

D&I initiatives like these supporting diverse students as well as faculty from CC/TCU/MSI (where many diverse students begin their science careers) bring important perspectives to our Society’s activities and leadership. Making D&I events and resources broadly available at the Botany conference and in other venues is an important step towards engaging the entire Botany community in efforts to encourage the diversity of plant scientists within the BSA and the plant sciences as a whole. It’s critically important to honor the voices and perspectives of these students and faculty to continue to foster a welcoming, inclusive environment at our conferences, and to live up to the aspirations of our Society’s mission and goals.

## ACKNOWLEDGMENTS

Thanks are due to all the D&I program participants, advisory board members, speakers, as well as the PLANTS program leaders, administrators, and mentors and to the Botany conference planning team and staff who helped to make this grant successful.

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# FROM THE *PSB* ARCHIVES

## 60 years ago:

“Dr. Sherwin Carlquist has recently received a grant from the National Science Foundation which will enable him to pursue his studies on the genus *Scaevola* (Goodeniaceae). Because this genus is most widespread in Pacific regions, Dr. Carlquist expects to depart in June and spend most of his forthcoming sabbatical year surveying the plants of this genus on the islands of the Pacific Ocean. Dr. Carlquist is Associate Professor of Botany in the Claremont Graduate School, and a staff member of the Rancho Santa Ana Botanic Garden in Claremont, California.

Announcements *PSB* 8(1): 11.

Editor's note: An in memoriam for Dr. Carlquist can be found on p. 66. Sixty years ago, the Editor-in-Chief of *Plant Science Bulletin* was William L. Stern (see p. 73).

## 50 years ago:

William T. Gillis writes the lead article about the Fairchild Tropical Garden. “Have you ever heard of a garden that sponsors the region's largest white elephant sale, grows no annual plants, sometimes has to plant trees with a stick of dynamite, and invites the public to walk on the grass? The Fairchild Tropical Garden near Miami, Florida, is such a garden.”

Gillis, William T. Continental America's Tropical Garden. *PSB* 18(1): 2-4

## 40 years ago:

C. K. Sheng writes the lead article about the history of plants and Botanic Gardens in China “Upon the founding of the People's Republic, plant introduction developed into an organized and scientific enterprise. Since 1954, ten major botanic gardens in different climates and vegetational regions were established under the sponsorship of Academia Sinica. A Commission of Botanic Gardens was established under the Academy and, according to the Rules of Botanic Gardens (1978), five functions should be performed:

1. The exploitation of wild plant resources, introduction of indigenous and exotic economic plants, breeding of new varieties so as to enrich the resources of cultivated plants.
2. To study the new techniques and methods on plant introduction and acclimatization, so as to improve the productivity, quality or tolerance of introduced plants.
3. To summarize the principles regulating the growth, development, adaptability, economic characteristics and variation of introduced plants.
4. Extensive collection of plant resources, especially those of rare, threatened and endangered species, followed by studies on their evolution, taxonomy, preservation and utilization.
5. To mold a botanical garden with both pleasing landscapes and scientific displays, to make the garden an important place to study modern botany and to popularize botanic knowledge in the public.”

Sheng, C.K. Plant Introduction and Botanic Gardens in China. *PSB* 28(1): 25-28

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## PlantingScience Digging Deeper Research Published

The Education team is pleased to announce the formal publication of the results of our Digging Deeper research partnership (Taylor et al., 2022). Initiated in 2016, this large-scale research study showed the effectiveness of the PlantingScience Power of Sunlight theme for increasing students' content knowledge around photosynthesis/cellular respiration and in improving their attitudes about scientists. For a summary of the research and our findings, see our press release at: <https://www.eurekalert.org/news-releases/945679>.

PlantingScience! During the Fall 2021 session, we had groups from 24 schools, comprising 1018 students—the highest participation rate we have experienced since 2018. The groups used a wide variety of themes this session as well; factors affecting seed germination (The Wonder of Seeds) was the most popular, but groups also studied Brassica and Arabidopsis genetics, tree ecology, plant tissues, and photosynthesis. Combined with our unusually large Spring 2021 session, PlantingScience has shown considerable growth over previous years, even prior to the pandemic.

### UPDATE ON PLANTINGSCIENCE

Between mask mandates, vaccination requirements, and students readjusting to a school day routine after a year spent learning from home, teachers have had a lot to juggle this school year. Nonetheless, they returned to

Our Spring 2022 session began on February 14. This session is somewhat smaller, but as we look ahead to the upcoming F2 research planned for 2023, we are working with our platform developer to make important programming updates and improvements. We are excited about the days to come and proud to facilitate the amazing partnership that makes this incredible mentoring opportunity available to teachers and students.



**By Dr. Catrina Adams,** *Education Director*



**Jennifer Hartley,** *Education Programs Supervisor*

Please join us as a mentor! We are particularly short on mentors who are comfortable mentoring for our Pollen and Pollination, Agronomy Feeds the World, and Power of Sunlight (photosynthesis and respiration) themes right now. Learn more about these and other investigation themes here: <https://plantingscience.org/investigationthemes>.



# PLANTINGSCIENCE

## DIGGING DEEPER TOGETHER

SUMMARY OF RESEARCH RESULTS 2015-2021

### THANK YOU FOR YOUR PARTICIPATION!

The Digging Deeper Research Study was a success because of the participation of districts from across the country. We appreciate the time and effort of participating teachers and students, and the scientists who supported them.



### PROGRAM PARTICIPANTS INCLUDED:

**66** TEACHERS  
working with  
**~3000 STUDENTS\***

**43** LIAISONS (EARLY-CAREER  
SCIENTISTS)  
working with  
**400+ MENTOR SCIENTISTS**

*\*Schools in the study were very similar to the overall US population with respect to student composition.*



### STUDY GOALS:

Digging Deeper was a research study designed to investigate **the effectiveness of a partnership program involving high school students, teachers, and scientist mentors** for improving students' science learning.

### KEY FEATURES:

**Fully randomized control design**  
*This research design is the gold standard for intervention research in education.*

**One week of in-person collaborative professional learning**  
*Teachers and early-career scientists participated in a workshop to prepare them to co-mentor student teams through plant science investigations.*

**Teachers taught the PlantingScience Power of Sunlight module to students**  
*Students took part in guided and open investigations to explore photosynthesis and cellular respiration.*

**Students communicated with mentor scientists online**  
*During the Power of Sunlight module, student teams collaborated with their scientist mentor using the PlantingScience platform.*



# RESULTS

## OF THE DIGGING DEEPER RESEARCH PROJECT



STUDENTS IN THE PLANTINGSCIENCE TREATMENT GROUP SHOWED GREATER GAINS IN

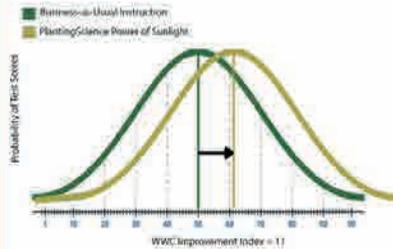
CONTENT KNOWLEDGE AND ATTITUDES ABOUT SCIENTISTS

THAN STUDENTS IN THE COMPARISON GROUP

### QUESTIONS? CONTACT:

Catrina Adams  
Botanical Society of America  
cadams@botany.org

### WHAT WE LEARNED:



The What Works Clearinghouse Improvement Index indicates that students who participated in the PlantingScience *Power of Sunlight* program would be expected to outperform students who did not receive the intervention by

**11 percentage points** on average.

### FULL RESULTS OF THE STUDY

IN THE JOURNAL OF RESEARCH IN SCIENCE TEACHING

Taylor, J. A., Adams, C. T., Westbrook, A. L., Creasap Gee, J., Spybrook, J. K., Kowalski, S. M., Gardner, A. L., & Bloom, M. (2022). The effect of a student-teacher-scientist partnership program on high school students' science achievement and attitudes about scientists. *Journal of Research in Science Teaching*, 59(3): 423-457. <https://doi.org/10.1002/tea.21733>

### WHAT'S NEXT?

Due to the success of Digging Deeper, the National Science Foundation has funded a continuation of the research. The new project will focus on **repeating the study, as replication studies are much needed but rarely done** in education research. The new research will also include **comparing the effectiveness of professional learning delivered in-person with an equivalent online collaborative teacher-scientist professional learning**. The next round of research will take place 2023-2024.



### GET INVOLVED!

The *Power of Sunlight* module, and other PlantingScience modules are available for free for any teacher. All modules provide the opportunity for students to interact online with scientist mentors. Visit <https://plantingscience.org> to learn more.



This material is based upon work supported by the National Science Foundation under DRK-12 #1502892 and #2010556. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## LIFE DISCOVERY CONFERENCE 2021

The question of whether conferences will ever be the same after the pandemic has been on the minds of every conference organizer since the global shutdown in 2020. This was no less true for the team organizing the 2021 Life Discovery Conference, which was held in Estes Park, Colorado this past September. Organized by the Ecological Society of America in partnership with the BSA and the Society for the Study of Evolution, the Life Discovery Conference brings together life science educators from high schools, community colleges, and universities to discuss best practices in biology education. The 2021 conference's theme was "Pushing Past Barriers: Ecological Science for All," and it sought to focus on ways to underscore the relevance of ecological and biological science to all students, regardless of life situation, cultural background, or career trajectory. Sessions addressed technology tools to facilitate communication and accessibility, citizen science opportunities to engage students in data collection and analysis, and use of the "4DEE" (Four-Dimensional Ecology Education) framework to guide pedagogical approaches at all levels, including both majors and non-majors in higher education settings.

The conference was held in-person as scheduled! For many it was the first face-to-face conference we had attended in nearly two years. As you might expect, strict safety protocols were implemented. Seventy-five educators attended, representing a range of university, community college, and high school. Many thanks to all who attended, to the organizing committee, to the YMCA of the Rockies for hosting, and to the University of Colorado for its sponsorship!

Organization of the 2023 Life Discovery Conference is underway. If you are interested in attending this exciting life science education-focused conference, visit <https://www.esa.org/ldc/> for the most updated information.

## UPDATED TEACHING RESOURCES

Be sure to check out our recently updated Teaching Resources page at [https://botany.org/home/resources/online\\_resources.html](https://botany.org/home/resources/online_resources.html).

Originally created to provide support to those teaching plant-related topics during the pandemic, this page has been revised and reorganized to provide an updated list of available resources to teachers and instructors at all levels. The list includes video collections, interactive websites, blogs, articles, and more!

If you have favorite web resources that you feel should be added to this page, contact Jennifer Hartley at [jhartley@botany.org](mailto:jhartley@botany.org). We will continue to update this list regularly.

## REFERENCES

Taylor, J., A. Westbrook, C. Adams, J. Creasap-Gee, J. K. Spybrook, S. M. Kowalski, A. L. Gardner, and M. Bloom 2022. The effect of participation in a student-scientist partnership-based online plant science mentoring community on high school students' science achievement and attitudes about scientists. *Journal of Research in Science Teaching*. 59: 423–457. <https://doi.org/10.1002/tea.21733>

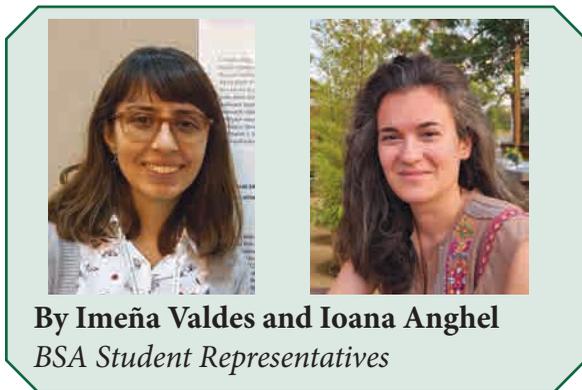


# STUDENT SECTION

## Roundup of Student Opportunities

It's that time of the semester where you start to compile every opportunity you want to apply to into one list. To make this easier for you, we have compiled a list of all the opportunities we know about. Even if the deadline of this application cycle is passed for this academic year, make sure to check by the end of this year for the next application cycle. Below, we have divided these into categories for easy browsing that include the following: BSA Grants and Awards, Fellowship, Research Awards, Broader Impacts, Short Courses and Workshops, Job Hunting, and ways that may help you to travel to Botany 2022.

Of course, all the grants and awards information will also be announced and reminded via the BSA social media, so make sure to follow us on Facebook (Botanical Society of America), Twitter (@Botanical\_), and Instagram (@botanicalsocietyofamerica), and stay updated! Also feel free to reach out to your BSA student representatives, Imeña (imenavaldes2020@u.northwestern.edu) and Ioana (studentrep1@botany.org), if you have questions about the listed opportunities, or any questions or comments about BSA.



## BSA GRANTS AND AWARDS

Here we listed a number of grants and awards offered by BSA this year, and make sure to pay attention to the deadlines. All the BSA awards are open to its members and students of any career stage and any nationality are encouraged to apply.

Donald R. Kaplan Award in Comparative Morphology		
Amount: \$10,000	Deadline: April 1	Purpose: Research Funds
More Info: <a href="https://cms.botany.org/home/awards/awards-for-students/kaplancomparativemorphology.html">https://cms.botany.org/home/awards/awards-for-students/kaplancomparativemorphology.html</a>		

<b>BSA Graduate Student Research Awards &amp; the J. S. Karling Award</b>		
Amount: \$1500	Deadline: April 1	Purpose: Research Funds
More Info: <a href="https://cms.botany.org/home/awards/awards-for-students/">https://cms.botany.org/home/awards/awards-for-students/</a>		

<b>BSA Graduate Student Research Awards Given by Sections</b>		
Amount: \$500	Deadline: April 1	Purpose: Research Funds
More Info: <a href="https://cms.botany.org/home/awards/awards-for-students/">https://cms.botany.org/home/awards/awards-for-students/</a>		

<b>BSA Undergraduate Student Research Awards</b>		
Amount: \$500	Deadline: April 1	Purpose: Research Funds
More Info: <a href="https://cms.botany.org/home/awards/awards-for-students/">https://cms.botany.org/home/awards/awards-for-students/</a>		

<b>BSA Young Botanist Award</b>		
Amount: NA	Deadline: April 1	Purpose: Recognition
More Info: <a href="https://cms.botany.org/home/awards/awards-for-students/bsayoungbotanistawards.html">https://cms.botany.org/home/awards/awards-for-students/bsayoungbotanistawards.html</a>		

## FELLOWSHIPS

Fellowships fund you during your graduate or postdoctoral work. Here we summarize some of the available fellowships that could be applicable to your graduate or postdoctoral work.

<b>American Association of University Women (AAUW) Dissertation Fellowship</b>	
Amount: \$20,000	Deadline: November 1
Nationality/Affiliation requirement: Must be a female U.S. citizen, national, or permanent resident	
Purpose: Dissertation Fellowships offset a scholar's living expenses while she completes her dissertation. The fellowship must be used for the final year of writing the dissertation. Applicants must have completed all course work, passed all preliminary examinations, and received approval for their research proposals or plans by the preceding November.	
More info: <a href="https://www.aauw.org/what-we-do/educational-funding-and-awards/american-fellowships">https://www.aauw.org/what-we-do/educational-funding-and-awards/american-fellowships</a>	

<b>American Association of University Women (AAUW) International Fellowship</b>	
Amount: \$18,000 – \$30,000	Deadline: November 15
Nationality/Affiliation requirement: Have citizenship in a country other than the U.S. or possession of a nonimmigrant visa if residing in the U.S.	
Purpose: International Fellowships are awarded for full-time study or research in the United States to women who are not U.S. citizens or permanent residents. Both graduate and postgraduate studies at accredited U.S. institutions are supported.	
More info: <a href="http://www.aauw.org/what-we-do/educational-funding-and-awards/international-fellowships/if-application/">www.aauw.org/what-we-do/educational-funding-and-awards/international-fellowships/if-application/</a>	

<b>Research Fellowships/Awards from the Arnold Arboretum</b>	
Amount: Up to \$10,000	Deadline: February 1
Nationality/Affiliation requirement: Fellowships differ in requirements.	
Purpose: Multiple awards and/or fellowships are offered for undergraduate and graduate students with topics that focus on Asian tropical forest biology and comparative biology of woody plants.	
More info: <a href="https://arboretum.harvard.edu/research/programs-and-opportunities/">https://arboretum.harvard.edu/research/programs-and-opportunities/</a>	

<b>Banting Postdoctoral Fellowships</b>	
Amount: \$70,000 per year	Deadline: Unknown for 2022
Nationality/Affiliation requirement: Open to Canadian citizens and permanent residents of Canada.	
Purpose: To promote research in Canada and Canadian scholars abroad.	
More info: <a href="https://banting.fellowships-bourses.gc.ca/en/home-accueil.html">https://banting.fellowships-bourses.gc.ca/en/home-accueil.html</a>	

<b>Burroughs Wellcome Fund: Career Awards at the Scientific Interface</b>	
Amount: \$500,000 over five years	Deadline: January 7
Nationality/Affiliation requirement: Open to U.S. and Canadian citizens, permanent residents, and temporary residents.	
Purpose: To bridge advanced postdoctoral training and the first three years of faculty service. Research bridging computational and biological approaches; PhD typically in chem, physics, math, etc.	
More info: <a href="https://www.bwfund.org/grant-programs/interfaces-science/career-awards-scientific-interface">https://www.bwfund.org/grant-programs/interfaces-science/career-awards-scientific-interface</a>	

### Ford Foundation Fellowship Programs

Amount: \$27,000 – \$50,000 for 1–3 years

Deadline: 2023–2024 competition will open December

Nationality/Affiliation requirement: All U.S. citizens, U.S. nationals, and U.S. permanent residents (holders of a Permanent Resident Card), as well as individuals granted deferred action status under the DACA Program.

Purpose: Three fellowship types are offered: Predoctoral, Dissertation, and Postdoctoral. The Ford Foundation seeks to increase the diversity of the nation’s college and university faculties.

More info: <https://sites.nationalacademies.org/PGA/FordFellowships/index.htm>

### Fulbright U.S. Student Program Study/Research Award

Amount: Variable

Deadline: 2023–2024 competition will open April

Nationality/Affiliation requirement: Must be citizens or nationals of the U.S. at the time of application; permanent residents are not eligible.

Purpose: Covers transportation and living expenses in the host country. Tuition and school-related fees covered in some countries.

More info: <https://us.fulbrightonline.org/applicants/types-of-awards/study-research>

### National Science Foundation Graduate Research Fellowship Program (NSF GRFP)

Amount: \$34,000 per year + tuition aid

Deadline: October

Nationality/Affiliation requirement: Must be a U.S. citizen, national, or permanent resident.

Purpose: Support outstanding graduate students in NSF-supported disciplines who are pursuing research-based Master’s and doctoral degrees at accredited U.S. institutions.

More info: <https://www.nsfgrfp.org/>

### National Science Foundation: Earth Sciences Postdoctoral Fellowships

Amount: \$90,000 per year

Deadline: October 2

Nationality/Affiliation requirement: Must be a U.S. citizen, national, or permanent resident.

Purpose: Earth science research including geobiology and paleobiology; current theme: “issues relating to scale.”

More info: [https://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=503144&org=NSF](https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503144&org=NSF)

### Postdoctoral Research Fellowships in Biology (PRFB)

Amount: Varies	Deadline: Varies
Nationality/Affiliation requirement: All U.S. citizens, U.S. nationals, and U.S. permanent residents.	
Purpose: The Directorate for Biological Sciences (BIO) awards Postdoctoral Research Fellowships in Biology (PRFB) to recent recipients of the doctoral degree for research and training in selected areas supported by BIO and with special goals for human resource development in biology. The fellowships encourage independence at an early stage of the research career to permit Fellows to pursue their research and training goals in the most appropriate research locations regardless of the availability of funding for the Fellows at that site.	
More info: <a href="https://www.jsps.go.jp/english/e-fellow/index.html">https://www.jsps.go.jp/english/e-fellow/index.html</a>	

### Schlumberger Foundation Faculty for the Future Fellowship

Amount: Up to \$50,000 per year	Deadline: 2023–2024 competition will open in November.
Nationality/Affiliation requirement: Applicant has to be a woman from developing/emerging economies.	
Purpose: The program's long-term goal is to generate conditions that result in more women pursuing scientific careers by lowering the barriers women face when entering STEM disciplines, thus reducing the gender gap. Faculty for the Future Fellows are expected to return to their home countries after completion of their studies to contribute to economic, social, and technological advancement by strengthening the STEM teaching and research faculties of their home institutions.	
More info: <a href="https://www.facultyforthefuture.net/content/about-faculty-future-program">https://www.facultyforthefuture.net/content/about-faculty-future-program</a>	

### Smithsonian Institution Fellowships

Amount: up to \$40,000 for one year	Deadline: November
Nationality/Affiliation requirement: None	
Purpose: To support research in residence at Smithsonian Institution facilities. All fields of study that are actively pursued by the museums and research organizations of the Smithsonian Institution are eligible.	
More info: <a href="https://fellowships.si.edu/fellowship-programs">https://fellowships.si.edu/fellowship-programs</a>	

<b>Switzer Fellowship</b>	
Amount: \$15,000	Deadline: January 2023
Nationality/Affiliation requirement: U.S. citizen, permanent resident, Deferred Action for Childhood Arrivals (DACA) recipient, or a refugee or asylee according to the definition provided by the U.S. Department of Homeland Security; and be enrolled in an accredited graduate institution only in California or one of the six New England states (ME, NH, VT, MA, CT, RI).	
Purpose: To support graduate students from diverse academic and personal backgrounds in New England and California whose studies and career goals are directed toward environmental improvement.	
More info: <a href="https://www.switzernetwork.org/become-fellow">https://www.switzernetwork.org/become-fellow</a>	

## RESEARCH AWARDS

In addition to those we listed, check out local Societies (e.g., Florida Native Plant Society, Southern Appalachian Plant Society, Washington Native Plant Society Grant, Montana Native Plant Society Grant, Nevada Native Plant Society Margaret Williams Research Grant, Colorado Native Plant Society John W. Marr Research Grant, California Native Plant Society Educational Grants and Chapter Scholarships, Arctic Institute of NA Grants-in-Aid Program). Other labs have great databases too! Check out the Rothfels Lab database at <https://rothfelslab.berkeley.edu/resources/funding-sources/> (thanks, Thomas Murphy!) or the Northwestern University Plant Biology and Conservation Program grant opportunities database (<https://plantbiology.northwestern.edu/graduate/resources/grants.html>). Another great way to find more grant sources is to check out the CVs of botanists you admire and look up the grants and fellowships they have received.

<b>American Society of Plant Taxonomists Graduate Student Grants</b>	
Amount: Up to \$1,500	Deadline: February 28
Nationality/Affiliation requirement: Must be a member of the Society.	
Purpose: To fund Master's and doctoral students to conduct fieldwork, herbarium studies, and/or laboratory research in any area of plant systematics.	
More info: <a href="https://www.aspt.net/awards#.YfnrnvXML0p">https://www.aspt.net/awards#.YfnrnvXML0p</a>	

<b>Awards from New England Botanical Club</b>	
Amount: Up to \$3,000	Deadline: February 5
Nationality/Affiliation requirement: None.	
Purpose: To encourage botanical research in the New England region.	
More info: <a href="https://www.rhodora.org/awards/graduate.html">https://www.rhodora.org/awards/graduate.html</a>	

### Company of Biologists: Travelling Fellowships

Amount: Up to £2,500

Deadline: February, May, August, October, of each year

Nationality/Affiliation requirement: Award cannot be paid to those in areas that have sanctions, embargoes, or other political trade restrictions put in place by the United Nations, the EU or the UK.

Purpose: Lab visits to work with collaborators; research themes must be covered by Company of Biologists journals.

More info: <https://www.biologists.com/travelling-fellowships/>

### Evolutionary, Ecological, or Conservation Genomics (EECG) Research Award

Amount: Up to \$6,000

Deadline: 2023–2024 competition will open in December

Nationality/Affiliation requirement: Must be a member of the society.

Purpose: Priority for funding will be given to proposals that address genome-scale questions, or ecological, evolutionary, and conservation genetics questions that are best addressed using genomic approaches in a hypothesis-testing framework.

More info: <https://www.theega.org/eecg-awards.php>

### Garden Club of America Scholarship

Amount: \$1,000 – \$8,000

Deadline: Varies

Nationality/Affiliation requirement: U.S. citizens and permanent residents who are enrolled in a U.S.-based institution.

Purpose: To encourage research focused on systematics, also projects of a more general or educational nature will be considered, provided that they include a strong systematics component. Offers a total of 28 merit-based scholarships and fellowships in 12 areas related to conservation, ecology, horticulture, and pollinator research.

More info: [www.gcamerica.org/scholarships](http://www.gcamerica.org/scholarships)

### Grants from the Wetland Foundation

Amount: Up to \$2,000

Deadline: December 18

Nationality/Affiliation requirement: Any student currently enrolled full-time at an academic institution in the U.S.

Purpose: To support wetland education and research.

More info: <http://thewetlandfoundation.org/grants/>

### Herb Society of America Research Grant

Amount: \$10,000	Deadline: January 31
Nationality/Affiliation requirement: Only U.S. residents may apply.	
Purpose: This grant is for the research of the horticultural, scientific, and/or social use of herbs throughout history.	
More info: <a href="https://www.herbsociety.org/get-involved/grants-scholarships/">https://www.herbsociety.org/get-involved/grants-scholarships/</a>	

### International Association for Plant Taxonomy Research Grant

Amount: Up to \$2,000	Deadline: February 28
Nationality/Affiliation requirement: None	
Purpose: To fund students and young investigators preferably for travel to institutions, laboratory investigations, or fieldwork.	
More info: <a href="https://www.iaptglobal.org/grants">https://www.iaptglobal.org/grants</a>	

### Lewis and Clark Fund for Exploration

Amount: Up to \$5,000	Deadline: November
Nationality/Affiliation requirement: U.S. citizens and residents wishing to carry out research anywhere in the world. Foreign applicants must either be based at a U.S. institution or plan to carry out their work in the U. S.	
Purpose: To fund field exploration in various fields.	
More info: <a href="https://www.amphilsoc.org/grants/lewis-and-clark-fund-exploration-and-field-research">https://www.amphilsoc.org/grants/lewis-and-clark-fund-exploration-and-field-research</a>	

### National Geographic Level I Grant

Amount: Up to \$20,000	Deadline: April 13
Nationality/Affiliation requirement: None	
Purpose: Support research, conservation, and exploration-related projects consistent with National Geographic's existing grant programs. In addition, this program provides increased funding opportunities for fieldwork in 18 Northeast and Southeast Asian countries.	
More info: <a href="https://www.nationalgeographic.org/grants/grant-opportunities/">https://www.nationalgeographic.org/grants/grant-opportunities/</a>	

<b>P.E.O. Scholar Award</b>	
Amount: \$20,000	Deadline: Between August 20 and November 20
Nationality/Affiliation requirement: Must be a citizen or legal permanent resident of the U. S. or Canada.	
Purpose: To encourage research focused on systematics, also projects of a more general or educational nature will be considered, provided that they include a strong systematics component.	
More info: <a href="https://www.peointernational.org/psa-eligibility-requirements">https://www.peointernational.org/psa-eligibility-requirements</a>	

<b>Botany in Action Fellowship at Phipps Conservatory and Botanical Gardens</b>	
Amount: \$5,000	Deadline: January 2023
Nationality/Affiliation requirement: Must be enrolled in a PhD program at a U.S. graduate institution (U.S. citizenship is not required)	
Purpose: To support emerging plant-focused scientists through research grants and science communication training.	
More info: <a href="https://www.phipps.conservatory.org/green-innovation/for-the-world/botany-in-action">https://www.phipps.conservatory.org/green-innovation/for-the-world/botany-in-action</a>	

<b>Richard Evans Schultes Research Award</b>	
Amount: Up to \$2,500	Deadline: March 30
Nationality/Affiliation requirement: Must be a member of the Society for Economic Botany	
Purpose: To help defray the costs of field work on a topic related to economic botany for students who are members of the Society for Economic Botany.	
More info: <a href="https://www.econbot.org/index.php?module=content&amp;type=user&amp;func=view&amp;pid=50">https://www.econbot.org/index.php?module=content&amp;type=user&amp;func=view&amp;pid=50</a>	

### Sigma Xi Grants-in-Aid of Research

Amount: Up to \$1,000

Deadline: March 15; October 1

Nationality/Affiliation requirement: Preference will be given to members of the Society.

Purpose: To encourage close working relationships between students and mentors, this program promotes scientific excellence and achievement through hands-on learning.

More info: <https://www.sigmaxi.org/programs/grants-in-aid>

### Society for Herbarium Curators Student Research Awards

Amount: \$250 (undergrad) or \$500 (grad)

Deadline: February 1

Nationality/Affiliation requirement: Must be a member of the Society.

Purpose: To provide funds for graduate or undergraduate students conducting research related to herbarium resources.

More info: <https://www.herbariumcurators.org/awards>

### Society for Integrative and Comparative Biology Grant-in-Aid of Research (GAIR)

Amount: Up to \$1,000

Deadline: Fall 2022

Nationality/Affiliation requirement: Must be a member of the Society.

Purpose: For graduate students in support of their research in the fields of integrative and comparative biology.

More info: <https://sicb.org/grants-in-aid-of-research-program-giar/>

### Society for Integrative and Comparative Biology Fellowship of Graduate Student Travel (FGST)

Amount: Up to \$2,000

Deadline: Fall 2022

Nationality/Affiliation requirement: Must be a member of the Society.

Purpose: For graduate students for travel and other expenses at distant research laboratories, museums, or field sites.

More info: <https://sicb.org/fellowship-of-graduate-student-travel-fgst/>

<b>Society for the Study of Evolution Grants</b>	
Amount: \$2,500 – \$3,500	Deadline: Varies
Nationality/Affiliation requirement: Must be a member of the Society.	
Purpose: This Society has a range of grants that service students pursuing evolutionary research.	
More info: <a href="https://www.evolutionsociety.org/index.php?module=content&amp;type=user&amp;func=view&amp;pid=44#awards">https://www.evolutionsociety.org/index.php?module=content&amp;type=user&amp;func=view&amp;pid=44#awards</a>	

<b>Society of Systematic Biologist Graduate Student Research Award</b>	
Amount: Up to \$3,000	Deadline: Fall 2022
Nationality/Affiliation requirement: Must be a member of the Society.	
Purpose: To assist graduate students conducting research in systematics.	
More info: <a href="https://www.systbio.org/graduate-student-research-awards.html">https://www.systbio.org/graduate-student-research-awards.html</a>	

<b>The Councils of the Linnaean Society and the Systematics Association: Systematics Research Fund</b>	
Amount: £500 – £1,500	Deadline: Unknown for 2022
Nationality/Affiliation requirement: None	
Purpose: To encourage research focused on systematics, also projects of a more general or educational nature will be considered, provided that they include a strong systematics component.	
More info: <a href="https://systass.org/grants-and-awards/srf/">https://systass.org/grants-and-awards/srf/</a>	

<b>Explorers Club Grants</b>	
Amount: Varies	Deadline: Varies
Nationality/Affiliation requirement: Varies based on grant.	
Purpose: To encourage research focused on systematics, also projects of a more general or educational nature will be considered, provided that they include a strong systematics component.	
More info: <a href="https://www.explorers.org/grants/">https://www.explorers.org/grants/</a>	

### The Mohamed Bin Zayed Species Conservation Fund

Amount: Up to \$25,000	Deadline: February 28
Nationality/Affiliation requirement: Anyone directly involved in species conservation can apply to the Fund for a grant.	
Purpose: To support conservationists based in all parts of the world dealing with plant and animal species.	
More info: <a href="https://www.speciesconservation.org/grants/">https://www.speciesconservation.org/grants/</a>	

### Torrey Botanical Society Student Fellowship Award

Amount: Up to \$2,500	Deadline: January 15
Nationality/Affiliation requirement: Must be a member of the Society.	
Purpose: The Torrey Botanical Society supports student research in botanical research.	
More info: <a href="https://www.torreybotanical.org/grants-awards/torrey-botanical-society-grad-student-research-fellowship/">https://www.torreybotanical.org/grants-awards/torrey-botanical-society-grad-student-research-fellowship/</a>	

## BROADER IMPACT OPPORTUNITIES

Sharing your passion for plants and science with a wide range of audiences will help develop speaking skills as well as help you reconnect with why you decided to go to grad school after all, and they can add weight to your CV and resume as well. This is only a short list, but there are many more opportunities you can look into (e.g., Girls Who Code, Girls Scouts, Boy Scouts).

### PlantingScience

What is it?	A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
What you can do:	A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
More info:	<a href="http://www.plantingscience.org/">www.plantingscience.org/</a>

### Science Olympiad

What is it?	Competitions are like academic track meets, consisting of a series of 23 team events in each division (middle school or high school). Each year, a portion of the events are rotated to reflect the ever-changing nature of genetics, earth science, chemistry, anatomy, physics, geology, mechanical engineering and technology.
What you can do:	Mentor local students in person on a variety of science and engineering-oriented topics and skills, help organize and run competitions
More info:	<a href="http://www.soinc.org/">www.soinc.org/</a>

<b>Local Arboretums, Parks, Museums, and Herbaria</b>	
What is it?	These institutions often depend on volunteers to donate their time and expertise to help people of all ages enjoy their collections and grounds. They may already have programs in place that allow you to lead tours or interact with visitors at special events, so that you can share your interests and passion.
What you can do:	Lead tours, help organize and run events.
More info:	Look up local parks/arboretums/museums/herbaria online, or inquire at visitors' centers.

## SHORT COURSES AND WORKSHOPS

These are a great way to learn new research skills, which can also be added to your CV or resume. Due to COVID-19, many have been canceled but please double-check the websites for info! We provide the names and website links for a few short courses and workshops that have received very good feedback from their past participants.

- Summer Short Courses at the Arnold Arboretum (<https://arboretum.harvard.edu/research/programs-and-opportunities/>)
- Tropical Plant Systematics (<https://tropicalstudies.org/course/tropical-plant-systematic/>)
- Organization for Tropical Studies (OTS) Courses (<https://tropicalstudies.org/graduate-programs/>; <https://tropicalstudies.org/undergraduate-programs/> )
- Frontiers and Techniques in Plant Science (<https://meetings.cshl.edu/courses.aspx?course=C-PLAN&year=20>)
- Annual Workshops hosted by evomics.org (<https://evomics.org/>)
- Annual Workshop in Evolutionary Biology in Guarda (<https://www.evolution.unibas.ch/teaching/guarda/>)
- The Bee Course (<https://www.thebeecourse.org/>)
- Tropical Field Biology ([https://araceae.wixsite.com/tropical-botany?fbclid=IwAR0\\_](https://araceae.wixsite.com/tropical-botany?fbclid=IwAR0_))
- Jepson Herbarium at UC Berkeley Botanical Workshops (<https://ucjeps.berkeley.edu/workshops/>)
- RADcamp Workshops (<https://radcamp.github.io/>)

## WHAT'S NEXT: LOOKING FOR A JOB IN PLANT SCIENCES?

Before you complete your degree, or if you are looking to switch jobs, it is important to consider your next step—whether it's finding a PI and lab to work in for continuing your education, finding a postdoctoral research opportunity, or finding a job that suits your goals and skills. Finding out about jobs often happens through personal contacts, but there are great online resources as well.

### Internship Opportunities

Interning is important to gain experience, help you figure out what type of research or field you want a career in and network with those who are in it. This also doesn't always have to be done in a volunteer format. There are many different *paid* internships to apply to for the summer, with many of the deadlines in December or early next year. Many botanical gardens, arboretums, and museums offer internship opportunities during the summer, or even throughout the year, so make sure to check the job opportunities of their websites. Here we have a few examples of sites that you can search for internships:

- Botanical Society of America: [jobs.botany.org](http://jobs.botany.org)
- Research experiences for undergraduates (REU): [https://www.nsf.gov/crssprgm/reu/reu\\_search.jsp](https://www.nsf.gov/crssprgm/reu/reu_search.jsp)
- Internships offered by The Future Park Leaders of Emerging Change: <https://www.futureparkleaders.org/>
- Internships offered by the Organization for Tropical Studies (OTS) research stations in Costa Rica: <https://tropicalstudies.org/portfolio/internships/>
- Internship opportunities at the Smithsonian: <https://www.smithsonianofi.com/internship-opportunities/>
- Fall internship program offered by the National Tropical Botanical Garden: <https://ntbg.org/education/college>
- Summer internship offered at the Chicago Botanic Garden (REU): <https://pbcinternships.org/>
- Internship offered at Montgomery Botanical Center: <https://www.montgomerybotanical.org/research/education/#interns>
- Conservation and Land Management Internship Program: <https://www.clminternship.org/>
- Great Basin Institute AmeriCorps Internships: <https://www.vscyberhosting.com/greatbasin/Careers.aspx?type=HOTJOBS>

### Graduate/Post-Graduate Opportunities

These types of jobs are easily searchable on the “EvolDir” website under “PostDocs” and “GradStudentPositions”. Click the icon, and listings will pop up in a list from the newest to the oldest. This site shows positions from across the biological sciences, but it is a great option for plant evolutionary biologists. If you are interested in more of the ecology side of research, make sure to check out “ecolog.” Contact people from the university/college that you’re interested in to ask for more information.

- EvolDir: [https://evol.mcmaster.ca/cgi-bin/my\\_wrap/brian/evoldir/Jobs/](https://evol.mcmaster.ca/cgi-bin/my_wrap/brian/evoldir/Jobs/)
- Ecolog: <https://www.conservationjobboard.com/category/ecology-jobs>

### Academic Teaching Positions

Check the BSA website: click on the “Careers/Jobs” tab, and you can select the “Post-doctoral, Fellowship, and Career Opportunities” link to see a current list of a variety of job postings. The BSA website is a great resource for one-stop shopping for careers and other opportunities in a variety of botanical sciences. Another good resource for finding jobs (including postdoctoral opportunities) can be found through AAAS, at the Science Careers site.

- Botanical Society of America: <https://jobs.botany.org/>
- AAAS Science Careers: <https://jobs.sciencecareers.org/jobs/botany-plant-science/>

### Government Positions and Non-Academic Jobs

Searches for government jobs can begin at [usajobs.gov](http://usajobs.gov) and [americajobs.com](http://americajobs.com). A good resource for non-academic jobs is the Conservation Job Board; this site allows you to search within various fields by state and is updated regularly. Networking sites like LinkedIn and ResearchGate will help you connect with and organize your professional contacts; be sure to keep your profile pages updated and polished!

- Government positions: [www.usajobs.gov](http://www.usajobs.gov) and [www.americajobs.com](http://www.americajobs.com)
- Conservation Job Board: [www.conservationjobboard.com/category/botany-jobs](http://www.conservationjobboard.com/category/botany-jobs)

### Use your University!

Many academic institutions have offices that focus on helping alumni succeed after graduation. Check with your department or institution for resources on job announcements, workshops focused on personal development (such as CV/resume writing or getting a teaching certificate), and networking opportunities. Since Botany 2019, we have started to offer CV/resume reviewing booths for students to have their CV/resume viewed and commented on by professionals—more information regarding the schedules for Botany 2022 will come out soon, so stay tuned!

## GRANTS WILL HELP YOU TO TRAVEL TO BOTANY 2022

We would love to see you at Botany 2022! We outlined funding opportunities to help you afford joining us in Alaska!

### Use your University!

Check out your university's and department's funding for conference travel. Often universities have small internal grants for students (both undergraduate and graduate) to present at a conference. Due dates and amounts may vary by university. The Botany conference is always a great networking opportunity, making it an easy conference to justify attending.

## SOCIETY TRAVEL AWARDS

Both BSA and ASPT offer travel grants for Botany 2022. BSA travel grants are due May 1. ASPT has a travel grant lottery that is normally announced in March.

### BSA Student Travel Awards Given by Sections

**Amount:** Variable

**Deadline:** April–May

**Purpose:** Travel to the conference

**More info:** <https://cms.botany.org/home/awards/travel-awards-for-students/>

You can research your section leaders to ask about awards they are offering this year! BSA travel awards include: Pteridological Section & American Fern Society Student Travel Awards, Vernon I. Cheadle Student Travel Awards, Developmental & Structural Section Student Travel Awards, Ecological Section Student Travel Awards, Economic Botany Section Student Travel Award, and the Genetics Section Student Travel Awards, PUI Section Student Travel Awards, Bryological & Lichenological Section Travel Awards, and Phytochemical Section Student Travel Awards. Due to COVID-19, some of these awards have not been active. Double-check the website for updates!

### BSA Student and PostDoc Travel Award

**Amount:** \$500

**Deadline:** May 1

**Purpose:** Travel to the conference

**More info:**

[https://cms.botany.org/home/awards/travel-awards-for-students/grad\\_postdoc\\_travel.html](https://cms.botany.org/home/awards/travel-awards-for-students/grad_postdoc_travel.html)

Botany 2022 Travel Grants for Presenters from Developing Nations		
<b>Amount:</b> \$1,000	<b>Deadline:</b> May 1	<b>Purpose:</b> Travel to the conference
<b>More info:</b> <a href="https://botany.org/home/awards/awards-for-established-scientists/developing-nations-travel-grants.html">https://botany.org/home/awards/awards-for-established-scientists/developing-nations-travel-grants.html</a>		

PLANTS Grant	
<b>Amount:</b> Variable	<b>Deadline:</b> May 1
Purpose: Cover costs of travel, registration, food, and accommodation at the conference.	
<b>More info:</b> <a href="https://cms.botany.org/home/awards/travel-awards-for-students/plants-grants.html">https://cms.botany.org/home/awards/travel-awards-for-students/plants-grants.html</a>	
If you have never been to Botany, check out the PLANTS grant through BSA. The goal of this program is to enhance diversity at the Botany conferences. If you receive this grant, the cost of the conference is fully covered, you get paired with a senior and peer mentor to help you navigate the conference, and you'll be able to participate in networking and professional development opportunities. Check out more about the PLANTS program at the link above. BSA rep Imeña received this grant in 2015, so feel free to contact her if you have any questions!	

## EXTERNAL AWARDS

Bio REU Travel Grant (Rocky Mountain Biological Laboratory)	
<b>Amount:</b> Up to \$2,000	<b>Deadline:</b> At least 1 month prior to the conference
<b>Purpose:</b> To present your REU research at a conference.	
<b>More info:</b> Have you participated in an NSF-REU (National Science Foundation Research Experience for Undergraduate) within the three years? If so, you can request up to \$2,000 to present your REU research at a conference through the Rocky Mountain Biological Laboratory Bio REU travel grant ( <a href="https://www.rmbll.org/students/reu-travel-grant/">https://www.rmbll.org/students/reu-travel-grant/</a> ). You have to apply at least one month prior to the conference, and the total cost of the conference will be fully reimbursed after the conference.	

PP Systems Travel Grant	
<b>Amount:</b> Up to \$1,000	<b>Deadline:</b> Unknown for 2022
<b>Purpose:</b> To present research using the CIRAS-3 Portable Photosynthesis System at a conference.	
<b>More info:</b> Does your research utilize the CIRAS-3 Portable Photosynthesis System from PP Systems? And are you active on social media (“via your own lab blog, Twitter, etc.”)?	
If so, you could apply for up to \$1,000 to attend a conference or workshop through PP Systems ( <a href="https://tinyurl.com/bdevyh4t">https://tinyurl.com/bdevyh4t</a> ). BSA student member Rebekka Davis (University of Central Florida) received this grant to attend Botany 2019. See her video here ( <a href="https://www.youtube.com/watch?v=j2_Uj3pcLyI&amp;feature=youtu.be">https://www.youtube.com/watch?v=j2_Uj3pcLyI&amp;feature=youtu.be</a> ).	

## OTHER OPPORTUNITIES

Through BSA, there are many ways for students to have discounts on their registration. To have your registration reimbursed, you can volunteer with BSA at the conference. Keep a look out for emails from BSA soliciting volunteers sign-up; these emails will be sent closer to the conference dates. If you are part of the PlantingScience team, you can get half-off registration for the Botany conferences with a code that is distributed by the PlantingScience team. BSA Student Chapter members will also receive a small discount on registration; just make sure to select that you are a chapter member during registration.

## PAPERS TO READ FOR FUTURE LEADERS

As we continue in our careers, we hope to see the academic culture shift to be healthier and more inclusive. Below are a few papers we think you should read if you hope to lead. We hope to continue to recommend “Papers to Read for Future Leaders” to BSA Student members, if you have papers you would like us to include, please share it with us via this google form: <https://tinyurl.com/y5dp8r4m>! Previously shared papers include:

- Ålund, M., N. Emery, B. J. Jarrett, et al. 2020. Academic ecosystems must evolve to support a sustainable postdoc workforce. *Nature Ecology & Evolution* 13: 1–5.
- Asai, D. 2020. Race Matters. *Cell* 181: 754–757.
- Baker, K., M. P. Eichhorn, and M. Griffiths. 2019. Decolonizing field ecology. *Biotropica* 51: 288–292.
- Brown, N., and J. Leigh. 2020. Ableism in Academia: Theorising experiences of disabilities and chronic illnesses in higher education. London: *UCL Press*. DOI: <https://doi.org/10.14324/111.9781787354975>.
- Caviglia-Harris, J., K. E. Hodges, B. Helmuth, et al. 2021. The six dimensions of collective leadership that advance sustainability objectives: rethinking what it means to be an academic leader. *Ecology and Society* 26: 9.
- Chaudhury, A. and S. Colla. 2021. Next steps on dismantling discrimination: Lessons from ecology and conservation science. *Conservation Letters* 14: e12774.
- Chaudhary, V. B., and A. A. Berhe. 2020. Ten simple rules for building an antiracist lab. *PLOS Computational Biology* 16: e1008210.
- Claire Demery, A. J., and M. A. Pipkin. 2021. Safe fieldwork strategies for at-risk individuals, their supervisors and institutions. *Nature Ecology & Evolution* 5: 5–9.
- Cooper, K. M., A. J. J. Auerbach, J. D. Bader, et al. 2020. Fourteen recommendations to create a more inclusive environment for LGBTQ+ individuals in academic biology. *CBE - Life Science Education* 19:es6: 1–18.
- Cronin, M. R., S. H. Alonzo, S. K. Adamczak, et al. 2021. Anti-racist interventions to transform ecology, evolution and conservation biology departments. *Nature Ecology & Evolution*. 5: 1213–1223.
- Dewa, C. S., K. Nieuwenhuijsen, K. J. Holmes-Sullivan, et al. 2020. Introducing plant biology graduate students to a culture of mental well-being. *Plant Direct* 4: e00211.
- Ellis, E. C., N. Gauthier, K. K. Goldewijk, et al. 2021. People have shaped most of terrestrial nature for at least 12,000 years. *PNAS* 118: e2023483118.
- Emery, N. C., E. K. Bledsoe, A. O. Hasley, et al. 2020. Cultivating inclusive instructional and research environments in ecology and evolutionary science. *Ecology and Evolution* 11: 1480–1491.

- Gewin, V. 2021. How to include Indigenous researchers and their knowledge. *Nature* 589: 315–317.
- Hamilton, P. R., J. A. Hulme, and E. D. Harrison. 2020. Experiences of higher education for students with chronic illnesses. *Disability & Society* DOI:10.1080/09687599.2021.1907549.
- Huyck, J. J., K. L. Anbuhl, B. N. Buran, et al. 2021. Supporting Equity and Inclusion of Deaf and Hard-of-Hearing Individuals in Professional Organizations. *Frontiers in Education* DOI: <https://doi.org/10.3389/feduc.2021.755457>.
- MacKenzie, C.M., S. Kuebbing, R. S. Barak, et al. 2019. We do not want to “cure plant blindness” we want to grow plant love. *Plants, People, Planet* 1: 139–141.
- Maestre, F. T. 2019. Ten simple rules towards healthier research labs. *PLOS Computational Biology* 15: e1006914.
- McDaniel, S. F. 2021. Bryophytes are not early diverging land plants. *New Phytologist* 230: 1300–1304.
- McGill, B. M., M. J. Foster, A. N. Pruitt, et al. 2021. You are welcome here: A practical guide to diversity, equity, and inclusion for undergraduates embarking on an ecological research experience. *Ecology and Evolution* 11: 3636–3645.
- Nocco, M. A., B. M. McGill, C. M. MacKenzie, et al. 2021. Mentorship, equity, and research productivity: lessons from a pandemic. *Biological Conservation* 255: 108966.
- Parsley, K. M. 2020. Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet* 2: 598–601.
- Poodry, C. A. and D. Asai. 2018. Questioning Assumptions. *CBE - Life Sciences Education* 17: es7, 1–4.
- Schell, C. J., C. Guy, D. S. Shelton, et al. 2020. Recreating Wakanda by promoting Black excellence in ecology and evolution. *Nature Ecology & Evolution* 4: 1285–1287.
- Simoneschi, D. 2021. We need to improve the welfare of life science trainees. *PNAS* 118: e2024143118.
- Tseng, M., R. W. El-Sabaawi, M. B. Kantar, et al. Strategies and support for Black, Indigenous, and people of colour in ecology and evolutionary biology. *Nature Ecology & Evolution* 4: 1288–1290.



# ANNOUNCEMENTS

## IN MEMORIAM



**SHERWIN CARLQUIST**  
(1930–2021)

Dr. Sherwin Carlquist, known internationally for his lifetime of scholarly works in botanical science and photographic art, and by several generations of colleagues, students, and friends, died December 1, 2021 at the age of 91 at his home in Santa Barbara. A long-term member of BSA (65 years), plant anatomist at the Rancho Santa Ana Botanic Garden, professor at Pomona College and Claremont Graduate School, research botanist at the Santa Barbara Botanic Garden, and avid field researcher, he spent half a century traveling the world on National Science Foundation, National Geographic, and other grants and the force of his curiosity to author numerous seminal books on island biology, plant anatomy, and wood anatomy, as well as roughly 340 papers in peer-reviewed journals. More remarkable

than the quantity are his conceptual advances, with many ideas in wood anatomy and island biology explored for the first time.

Included among his pioneering advances are: the founding of “ecological” wood anatomy, the study of wood as reflecting function in the context of climate and habit; ideas regarding how small variations in developmental programs can lead to functional diversity (tracheid and fiber dimorphism, the functional interrelationship between axial parenchyma and imperforate tracheary elements); recognition of the functional importance of diversity in imperforate tracheary elements (tracheids, fiber-tracheids, libriform fibers, and vasicentric and vascular tracheids); the hypothesis that wider conduits are more vulnerable to drought-induced embolism than narrow ones; the hypothesis that the closest continental relatives of the Hawaiian silversword radiation are the tarweeds of California; pit membrane remnants in



*Sherwin mentoring high-school students in the scanning electron microscope laboratory at the Santa Barbara Botanic Garden. Each student published a peer-reviewed scientific paper.*

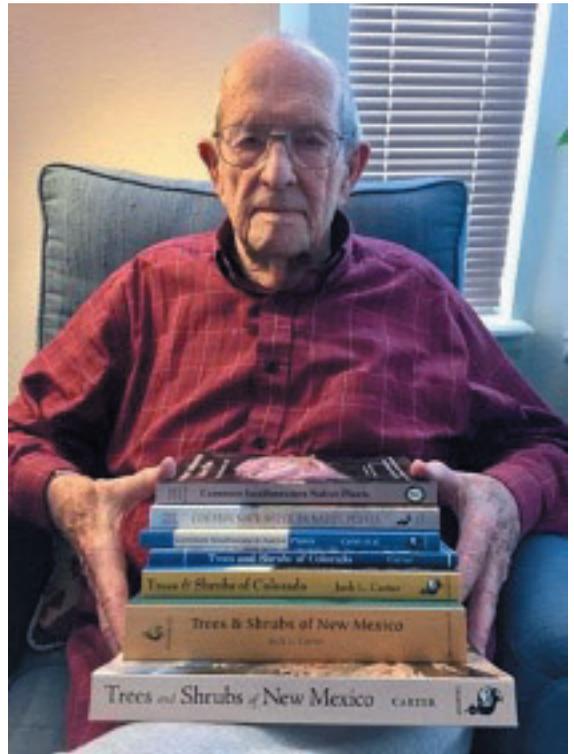
perforation plates of ferns and primitive dicotyledons; bordered pits in ray cells and axial parenchyma; successive cambia; monocot and gymnosperm xylem; evolution of vessels in Gnetales; and the functional significance of scalariform plates. More information about his research, publications, and field work is available at his website [www.sherwincarlquist.com](http://www.sherwincarlquist.com).

A Californian genus of Asteraceae, *Carlquistia*, is named for him, along with a species in the genus *Stylidium*, a hybrid *Huperzia* (Lycopodiaceae), and a fossil species of *Nuphar*. A genus of fossil wood, believed to be the oldest in South America, *Carlquistioxylon*, also commemorates him.

Sherwin viewed his legacy as inspiring people to build on his work and go beyond it, following their own inspiration and insights. He taught so many to risk being an outsider, to think critically, access courage, and find enormity in the everyday. He believed it was essential to choose things to care for, and know why they're worth it. His lifelong body of work will continue to speak for itself in both science and art, which is how he would have wanted it.

-By Dana Campagna, Mark Olson, and Ed Schneider

## IN MEMORIAM



## JACK LEE CARTER A TEACHING BOTANIST (1929–2020)

Long before the terrorist attacks of 9/11, one could walk onto the campus of the National Institutes of Health (NIH), in Bethesda, Maryland, from almost anywhere. There was no fence and no requirement to pass through security. So it was that I (J.D.M.) walked onto the campus with Jack Lee Carter on a spring morning in 1977—my first visit to NIH and my first meeting with the kind and gentle man who would become a long-time friend and colleague. We were on campus to attend a planning meeting for a new project on genetics education, being directed by the Biological Sciences Curriculum Study (BSCS). Jack, ever the botanist and teacher, wanted to show me the campus flora, and so we arrived early

and wandered around admiring the many beautiful native plants and the flower gardens, tended by a clearly devoted grounds crew. Jack, of course, knew what we were looking at. I did not, but I enjoyed the walk and the lesson, as Jack identified virtually every plant we encountered.

Our self-guided tour of the NIH campus was far from the only time Jack and I wandered around together. Some months later I joined the BSCS staff—in Boulder, Colorado—where I was expected to put my new degree in genetic counseling to work in the service of the organization’s burgeoning initiatives in human genetics education. Jack, by then on the biology faculty at Colorado College (CC), in Colorado Springs, was a regular visitor to BSCS, having been on the staff there for a couple of years in the mid-1960s. BSCS is one of those places whose mission ensures that you never really get away, even if you leave, and Jack continued to work on BSCS projects for many years. He knew the staff and administration very well and was well acquainted with the history and operation of the organization, including its approach to biology education, which still, after 63 years, emphasizes inquiry-based instruction. Jack’s regular visits to BSCS gave us a chance to spend more time together, on the job and off.

At the time we met, Jack was serving as the president of the National Association of Biology Teachers (NABT) and had served for four years as editor of the association’s journal, *The American Biology Teacher*. In 1984, he received NABT’s Honorary Membership, the association’s highest honor.

Jack’s professional preparation prepared him well for leadership in the science-education community. The first in his family to attend

college, Jack began his undergraduate work at Baker University in Baldwin, Kansas, in 1946–1947 and continued at Kansas State Teacher’s College (now Emporia State University) in Emporia, Kansas, where he received his B.S.

Jack was drafted into the U.S. Army in 1950 and served two years in Virginia during the Korean War, teaching the basics of chemical warfare to officers. He was realistic about his good fortune in escaping combat, telling friends and family that his college degree kept him from “getting his butt shot off in Korea.”

In 1951, Jack married his long-time Kansas sweetheart, Martha Shelton. After completing his M.S. at Emporia, he went on to earn a Ph.D. in botany at the University of Iowa in 1960, and began his teaching career at Simpson College in Indianola, Iowa. It was here that Jack began bending the minds of his students toward botany and plants. Tom Croat, the prolific plant collector from the Missouri Botanical Garden, was one of the first undergraduates to come under Jack’s spell. After several years at Simpson, Jack, Martha, and their young children returned to Emporia, where he taught at Emporia State until 1965. Jack then moved to BSCS for two years before taking a faculty position at CC, where he remained for 22 years, teaching botany and directing the herbarium, which now bears his name.

Jack was as committed to teaching as he was to botany. His classes at CC embraced the inquiry-driven strategies promoted by BSCS, and he collaborated with faculty in the education department to develop and improve instructional strategies in biology. CC’s well-known block plan, where students take one course at a time, allowed for extended field trips where students could observe and collect native plants from Colorado, New Mexico, and Arizona.

In 1982, BSCS relocated from Boulder to the CC campus, with two transplanted staff (including me) and Jack as half-time director. For a variety of fiscal and political reasons, this transition was a bit dicey, and there was some question about the organization's survival. Jack's ability as an administrator and his visibility in the science-education community, combined with the generosity of the CC administration and faculty, helped to guide BSCS through this difficult period. It is not an overstatement to say that BSCS might not have survived this rocky stretch were it not for Jack's leadership, connections, and political savvy.

I served as BSCS's associate director during Jack's three-year tenure at the helm, and we spent hours together working on matters of budget, organizational policy, personnel, and educational philosophy. For BSCS, that philosophy has always included a rigorous defense of the teaching of evolution, and Jack was an able advocate, continuing the organization's steadfast resistance to never-ending creationist attacks on its educational programs.

Our many hours together included extensive travel on BSCS business—trips that allowed us to develop a personal relationship built on mutual interests and a compatible worldview. Jack loved to discuss politics, and his sympathies were decidedly liberal, likely owing to his family origins. He was born in Kansas City, Kansas, on 23 January 1929 into a family with strong Democratic political affiliations. His grandfather was a U.S. marshal, sheriff of Wyandotte County, and a state senator. His father worked for the Santa Fe Railroad, and his mother was a homemaker. If Jack's political preferences ran to the left, they were more than anything pragmatic, and he could

not abide positions or policies that were not rooted in sound logic, irrespective of their party of origin.

Jack's advice and counsel remained immensely important as I assumed the BSCS directorship in 1985 and he returned to full-time status at CC. His knowledge of national trends in science education and his familiarity with campus politics were central to BSCS's renewed growth in its new location. I think Jack was happy to be relieved of the extra administrative burden at BSCS and delighted to be back with his students on collecting trips to the Southwest.

Jack's formal departure from BSCS did not, however, mean the end of our wandering around together. In addition to a shared political outlook, Jack and I shared a love of ice hockey, baseball, and beer—indulgences that we continued to pursue together for another 15 years, often with our spouses.

I left BSCS and Colorado in 1999 to return to the East Coast and did not see Jack often enough thereafter, though we did keep in touch. I'm reminded of Jack each time a new issue of the *New York Review of Books* shows up in my mailbox. It was one of his favorite periodicals, and he gave me my first subscription in the early 1980s. I've never let it lapse.

In addition to his active leadership in BSCS and NABT, Jack maintained a long-time membership in the Botanical Society of America and was active in ensuring the Society maintained a focus on plant education. Jack represented the Society on the CUEBS Biology Methods Advisory Group in the late 1960s (CUEBS gave rise to both AIBS and BSCS). I (M.D.S.) first met Jack at the 1990

annual meeting where he was a panelist on a symposium recounting CUEBS successes, and failures. This led to his appointment as a member of the section committee for Education and Teaching that authored the report for the BSA's *Botany for the Next Millennium* (1995). It was his good words and encouragement that led me to accept a position at Emporia State.

Throughout his retirement Jack maintained his interest in botanical education through leadership of both the New Mexico and Colorado Native Plant Societies and publishing statewide field guides: *Trees and Shrubs of Colorado*; *Trees and Shrubs of New Mexico*; *Common Southwestern Native Plants: an Identification Guide*; and *Gymnosperms of New Mexico: a Field Guide*.

Jack was always a gentleman whose kind words and wisdom helped shape our world and whose friendship will be sorely missed.

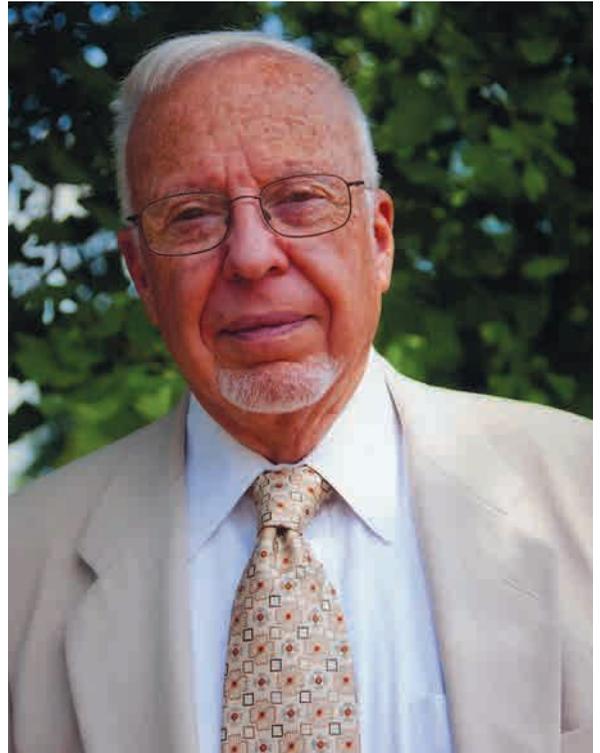
—*Joseph D. McInerney, Marshall D. Sundberg, and Gordon E. Uno*

*Joseph D. McInerney was on the staff of the Biological Sciences Curriculum Study for 22 years and was its director from 1985 to 1999. He was president of the National Association of Biology Teachers in 1991. He retired as executive vice president of the American Society of Human Genetics in 2017.*

*Marshall D. Sundberg, Roe R. Cross Professor of Botany, Emporia State University. Distinguished Fellow, BSA.*

*Gordon E. Uno, David Ross Boyd Professor of Botany, University of Oklahoma. Past President, BSA and NABT.*

## IN MEMORIAM



### ALAN GRAHAM (1934–2021)

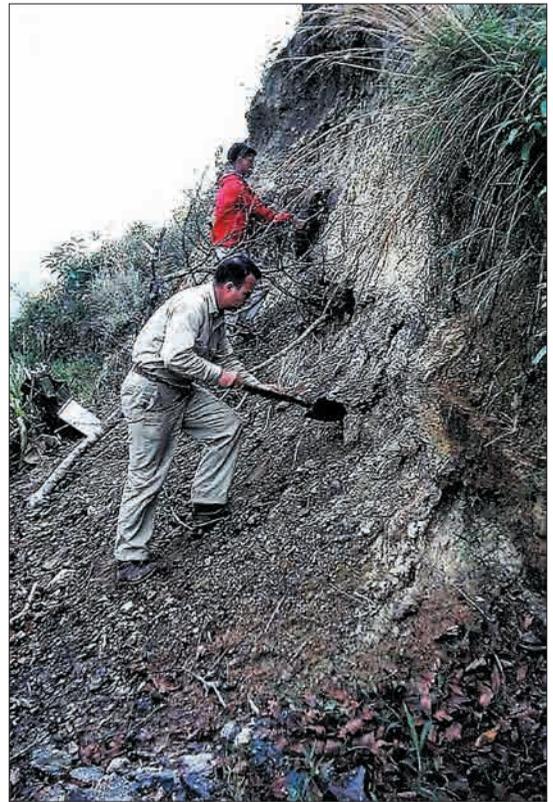
Alan Graham, Emeritus Professor of Botany and Geology at Kent State University and Curator of Paleobotany at the Missouri Botanical Garden, an incredibly productive scholar, highly awarded teacher and researcher, effective mentor, wide-ranging author, and a gentleman in the finest sense of the word, passed away at the age of 87 on July 8, 2021. He is survived by Shirley Graham, his wife and colleague of 61 years; his son Andrew and daughter-in-law Julia; daughter Alison; son Bruce; and granddaughter Kenzie Graham.

In 1520, grammarian Robert Whittington of Oxford College described Sir Thomas More as “a man for all seasons.” That phrase can have multiple meanings in the case of someone like

More, but common usage today suggests a person who, by preparation, personality, and character, has the ability to address the wide range of complex issues of a place and time. This certainly applies to Alan, whose place spanned the Americas, with a pioneering focus on Latin America, over a span of time from the Late Cretaceous through the entire Cenozoic.

This wide-ranging personal journey began at the University of Texas where Alan earned his Bachelor's degree with support from a full tennis scholarship. From there he moved on to the University of Michigan to study paleobotany under the direction of Chester Arnold. His PhD research involved a detailed study of fossil material in the Michigan collections from two Oregon Neogene sites: Succor Creek and Trout Creek. The standard of the day would have mandated a revision of the systematics of the two megafossil floras, along with observations of the implications with respect to paleogeography and paleoecology. Alan worked the megafossils of the two assemblages but added a prescient twist: the study of fossil pollen and spores derived from processing the rock matrix bearing the fossil leaves and other megafossil remains. Analysis of fossil pollen had evolved into a standard approach in the study of post-glacial sediments, particularly in north-temperate sites, but its primary application in older rocks was largely limited to providing data on the age and environments associated with petroleum exploration and field development (stratigraphic palynology). Trout Creek samples failed to yield useful pollen and spores, but many of the Succor Creek matrix samples were characterized by a rich fossil pollen/spore record. This led to the recognition of a number of new taxa in the Succor Creek assemblage and a broadening of the geographic and ecological implications

of the flora. This broadening of the scope of data in research on ancient assemblages would characterize virtually all of Alan's later work.



*Alan Graham and Enrique Martinez, Veracruz, Mexico, 1967*

It was during his time at Michigan that Alan met, courted, and married another PhD candidate in Botany, marking the start of a 61-year collaboration in life and science. With their newly-minted PhDs in hand, Alan and Shirley moved on to a one-year post-doc at Harvard University prior to moving on to permanent faculty positions at Kent State University in Ohio. From the outset, Alan was admired for the high quality of his teaching and research, his mentoring of both graduate and undergraduate students, and his ability to secure NSF grant support. His teaching reached far beyond the classroom and lecture hall, where, spread over 12 summer field

sessions, he led “Biological Field Studies in Mexico and the American West,” a life-changing encounter with the biodiversity and ecology of western North America. His exemplary teaching skills were clearly evident early in his career, when, in 1971, the Student Advisory Council of the Kent State University College of Arts and Sciences presented him with an Outstanding Teacher Award. In 1997 his university honored him with a Distinguished Scholar Award in recognition of his excellence and balance in teaching and research.

In his poem, “The Road Not Taken,” Robert Frost ends with a life-changing choice:

“Two roads diverged in a wood, and I ---  
I took the road less traveled by,  
and that has made all the difference.”

Alan Graham’s “road less traveled” was stunning in its scope, encompassing nothing less than the Cenozoic history of the American Neotropics, a region characterized by what is arguably the richest floristic diversity and ecological complexity on the planet. The consequences of the less-traveled road would be over 200 published papers, a pollen collection of over 35,000 reference slides of extant taxa, and paleobotanical and palynological collections sampling the paleodiversity and ancient plant associations across the New World tropics. Fundamental studies in paleobotany, bolstered by new insights on regional historical geology and geochronology, the incorporation of new insights into previously unknown climatic drivers, sea level changes, and a developing understanding of the role of land bridges—which both promoted and filtered the movement of plant taxa across vast areas of ancient landscapes—expanded Alan’s vision

from a regional to a continental perspective. His academic career ended with his retirement early in the new millennium, but he was far from finished with his life’s work. He and Shirley moved on to curator positions at the Missouri Botanical Garden in St. Louis for what was to be a virtual second career lasting 19 years until his passing.

The fruits of his continental-scale synthesis are to be found in several major awarded books: *A Natural History of the New World: The Ecology and Evolution of Plants in the Americas* (University of Chicago Press, 2010); *Late Cretaceous and Cenozoic History of Latin American Vegetation and Terrestrial Paleoenvironments* (Missouri Botanical Garden Press, 2010); and *Land Bridges: Ancient Environments, Plant Migrations and New World Connections* (University of Chicago Press, 2017).

Given the quality, scope, and recognition of his professional work, it was inevitable that awards should follow:

2009

**Distinguished Merit and Fellow Award**  
Botanical Society of America

**Asa Gray Award**

American Society of Plant Taxonomists

2011

**Paleobotanical Section Award**  
Botanical Society of America

2014

**A Festschrift for Alan Graham  
in His 80<sup>th</sup> Year**  
Missouri Botanical Garden

2018

**Jose Cuatrecasas Medal for Excellence in  
Tropical Botany**  
The Smithsonian Institution

Alan Graham was truly “A Man for All Seasons,” an exemplar of a life well-lived, and he will be missed. He leaves an indelible personal legacy, as well as the specimens and writings that are part of the fabric of his professional persona. That said, his best and most significant legacy can be found in his impact on his family, generations of students who passed through his classroom, the worldwide network of professionals whose work he has influenced, including his lasting impact in the American Tropics—his collaborators, students, those he has mentored and those he has inspired. Each of these individuals, to varying degrees, will continue to carry on and expand on the solid base of exemplary scholarship he has helped to create.

—*Ralph E. Taggart, PhD, Emeritus Professor of Plant Biology and Geological Sciences, Michigan State University*

## IN MEMORIAM

### WILLIAM LOUIS STERN (1926–2021)



*Bill Stern with Entada fruit, Panama, 1957*

Bill Stern, one of the world’s eminent wood anatomists and orchid scientists, passed away in Gainesville, Florida, at the age of 95 on November 1, 2021. He was a member of the “Greatest Generation”—those who grew up during the Depression and served in World War II. When the war ended, they were “mature beyond their years, tempered by what they had been through, disciplined by their military training and sacrifices” (Brokaw, 1998). Bill instilled the values he learned during wartime

in his students and collaborators alike—values such as selflessness and honor. In his quest for knowledge, there was never a margin for error or reason for injustice of any kind. At the same time, he had a profound sense of humor that allowed him to make lifelong friends and survive numerous physical ailments until the end, including malaria and Covid-19 before vaccines became available.

Bill was born on September 10, 1926, in Paterson, NJ. In 1944, a few months after he graduated from Paterson Central High School, he enlisted in the U.S. Navy at the age of 17 and served in Guam as a medical technician in the tuberculosis ward and fashioned false teeth. If he was allowed one indiscretion before his honorable discharge in 1946, it was to save up for the almost obligatory sailor's tattoo. Upon his return, he used the GI Bill to finance his studies at the National Farm School (now known as Delaware Valley University) in Doylestown, PA, before enrolling in Rutgers University and graduating *summa cum laude* with a B.S. in botany and minor in zoology in 1950. While studying in New Brunswick, he met secretary Flory Tanis on a blind date; their marriage in September 1949 would last for almost 50 years until her death in February 1999. He then undertook graduate studies at the University of Illinois, receiving his master's degree in botany (1951) after only one year and his doctorate in botany with minors in invertebrate zoology and paleobotany three years later. His dissertation was devoted to wood anatomy of Lauraceae. Bill customarily wore a suit as a teaching assistant and still a coat and tie on other school days. How times have changed!

After beginning his first professional posts as instructor and assistant professor in wood anatomy as well as curator of the S. J.

Record Memorial Collection of Woods at Yale University School of Forestry, he and Flory started a family, first their daughter Susan and then son Paul. While there, Bill taught courses in plant and wood anatomy and edited *Tropical Woods* for seven years (1953–1960). Fieldwork for research took him to the Florida Keys and Panama, supported by five different NSF grants from 1955 through 1961.



*Bill Stern, grad student, University of Illinois, 1952*

In 1960 he accepted an offer from the Department of Botany at the Smithsonian Institution as Curator of the Division of Woods, which became the Division of Plant Anatomy in 1963. He later served as Acting Chairman and then Chairman of the department from 1964 through June 1967, overseeing a faculty of 16. His research continued with

more fieldwork in Panama, Hawaii, Oregon, Jamaica, Dominica, and Luzon and Mindanao in the Philippines (where the family lived for a year); that led to the publication of several papers such as one in *Science* on the fossil forests of Ocú, Panama, with close friend and colleague, Dick Eyde (Stern and Eyde, 1963). In this era, he somehow managed to find the time to serve as Editor of *Plant Science Bulletin* (1962–1965) and Associate Editor of *BioScience* (1963–1966) and *Economic Botany* (1965–1975).

Bill left the Smithsonian in 1967 (but remained Research Associate) to accept a professorship at the University of Maryland, where he worked until 1979. Freedom from most administrative duties as department chairman left more time for research, editing professional journals, and more involvement on the national scene. His anatomical work focused on woody Saxifragaceae. Among his more ambitious projects were *Index Xylariorum* (institutional wood collections of the world), a treatment of Saxifragales for *Encyclopedia Britannica*, and the textbook *Humanistic Botany* with Oswald Tippo, his former advisor at the University of Illinois. Tippo later became Professor and Chancellor of the University of Massachusetts at Amherst and served as editor of the *American Journal of Botany* (1951–1953) and President of the BSA (1955). Bill was a founder and editor of *Biotropica* (1969–1972) and following that the editor of *Memoirs of the Torrey Botanical Club* (1972–1975). Toward the end of his tenure at Maryland, he served as Program Director of Systematic Biology at the National Science Foundation in Washington, DC.

Beginning when he gave Flory a *Cattleya* plant for Mother's Day in 1973, he became intrigued by orchids. Back then orchids were not the disposable commodity that they are today, and

so Bill needed to research how to keep that plant alive. What a mistake: one orchid became two, two became three, and soon he and son Paul were building a lean-to greenhouse against their townhouse in Silver Spring, MD. Systematic anatomy of Orchidaceae would become his principal academic focus in the last phase of his long career.

In 1979 the Department of Botany at the University of Florida was seeking a Chair. Bill applied, interviewed, accepted the offer, and moved with Flory to Gainesville. He remained Chair from September 1979 until August 1985. Part of his goal was to attract well-known orchid scientists and, with the Florida Museum of Natural History across the courtyard from his office in Bartram Hall, the University of Florida became a center for orchid studies in the United States. He was instrumental in helping Norris Williams, who specialized in orchid pollination and systematics, secure a position in the Museum and move to UF in 1981 with two of Norris's students from Florida State University: Mark Whitten (1954–2019) and me. Mark settled into the Museum and I into Bill's lab as postdoctoral research associates. Over the years Bill collaborated on projects involving developmental and systematic anatomy of orchids; the culmination of the vegetative work was volume 10 of the *Anatomy of the Monocotyledons* series published by Oxford University Press in 2014, 12 years after he was named Emeritus Professor of Botany.

Bill and Walter Judd team-taught an ongoing tropical botany course at Fairchild Tropical Garden in Coral Gables, Florida, in its early years. According to Judd (now Emeritus Professor), the course opened his eyes to tropical angiosperm diversity and made a positive impact on the students involved: "None of that could have happened without

Bill's administrative work and encouragement. Funding for summer field courses in biology is difficult to acquire—and Bill's support of the course (as a departmental offering) was critical in its long-term success." One of their shared doctoral students at UF was Barbara Carlsward, now Professor of Biological Sciences at Eastern Illinois University, who wrote that Bill "was a friend and valuable colleague who inspired his students to become more than they thought possible. He encouraged and challenged me both personally and academically like no one else I've ever known."

He maintained a strong service record with the BSA throughout his career, including election as President (1985–1986). He received the BSA Certificate of Merit in 1987 and another one in 1995 "honoring service and outstanding scholarship for the advancement of the botanical sciences." He also served as President of the American Society of Plant Taxonomists in 1981 and on the Board of Directors of the American Institute of Biological Sciences (1987–1989). One of his most valued honors was election as Fellow of the Linnean Society of London. It was at the Royal Botanic Gardens, Kew, that he met classical scholar and author of *Botanical Latin*, William T. Stearn (1911–2001); he chuckled when signing his correspondence to Stearn as "William Louis Stern, the later homonym."

Bill's selflessness and generosity persisted throughout his long life and professional career. When Jack Putz, newly hired as a plant

ecologist in the Department of Botany at UF in December 1982, arrived in Gainesville for the first time, Bill and Flory were out of town but had left their car for him in the airport parking lot with the keys to their house. A few years earlier at the University of Maryland, Bill had a student who was too nervous to stand up in front of a class or take his oral PhD exam. Bill found a therapist for this student—and paid for it. If someone needed help, he was always there to solve the problem. That was Bill Stern, everyone's dad and role model.

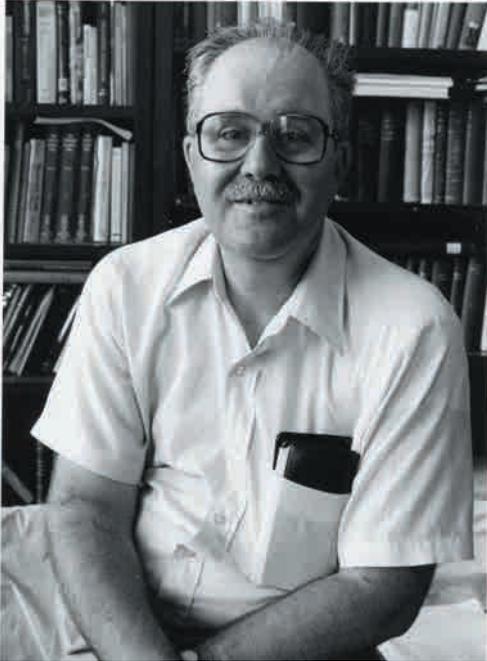
I thank Walter Judd, Jack Putz, Barbara Carlsward, James Ackerman, and most of all Susan Stern Fennell and Paul Stern for their reminiscences in preparing this tribute.

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## IN MEMORIAM

### RONALD L. STUCKEY (1938–2022)



*Ronald Stuckey in his office in July of 1987 in the former Botany and Zoology building on The Ohio State University campus. Photograph by A. E. Spreitzer.*

Ronald Lewis Stuckey was a good and kind person—someone you could not dislike. He loved plants, especially aquatics, and he was intrigued by how natural geological and landscape histories had shaped their distributions. He loved the histories of people, too, especially early botanists of the Ohio territories and the often-neglected contributions of women botanists. He was mindful of impacts of people on distributions of plants in Ohio and neighboring states, which fueled his support for their conservation. He might have been regarded as an eccentric, as are all academics, which made him more interesting to friends and colleagues—perhaps even more loveable.

Ron was born in Bucyrus, Crawford County, Ohio, on 9 January 1938 to Leora Irene (Shuey) and Guy Ralph Stuckey. For the first 18 years of his life, Ron lived on a farm in Lykens Township in Crawford County, where he attended high school. Following high school, Ron attended Heidelberg College in Tiffin, Ohio, where he majored in biology and worked as a biology assistant. He was a member of the Biological Honorary Society (Tri-Beta), serving as president for one year, and he also earned membership in the Heidelberg Honor Society. In his junior year (1959), he received the Zartman Award for superior work in biology, and in summer he attended the Franz Theodore Stone Laboratory of The Ohio State University on Gibraltar Island in Lake Erie, where he took university courses in field botany and aquatic mycology.

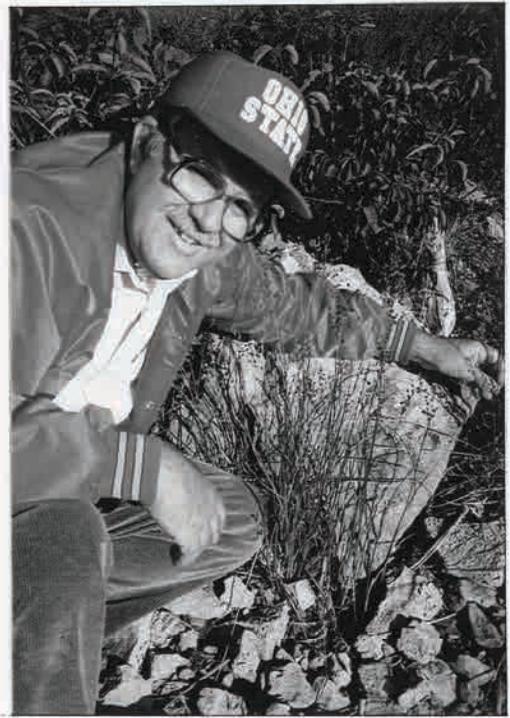
These academic successes motivated him to pursue graduate studies in botany, and he applied to and was accepted at the University of Michigan (Ann Arbor). In 1962 he was awarded an M.A. degree in Botany, on his way to a Ph.D. During the summers of 1961 and 1962, he served as an assistant for the aquatic plant course at the University of Michigan Biology Station at Pellston in the northern Lower Peninsula, coming under the influence of Prof. Edward G. Voss, who became his major professor. His dissertation topic was the taxonomy and phytogeography of the genus *Rorippa* (Brassicaceae: marsh cress). He received a graduate dissertation fellowship in his fifth year, which allowed full focus on *Rorippa*, for which he was granted a Ph.D. in May 1965 (published in 1972).

Ron applied for and was hired into a faculty position at The Ohio State University in 1965 and began teaching classes in general botany, local flora, and plant taxonomy. He was soon promoted to Associate Professor (1970) and

Professor (1978). In addition to his work in Columbus, he served for five weeks in the summer of 1973 as acting director of OSU's Franz Theodore Stone Laboratory in Lake Erie and directed the teaching program there from 1978 until 1985.

When Prof. Clara G. Weishaupt retired as curator of the OSU Herbarium, Ron was appointed to that position and served in this capacity from 1967 to 1976. This was an important change, because Prof. Weishaupt was trained as a plant physiologist and not a systematic botanist. Based on his experience at Michigan, Ron realized that many improvements needed to be made to the herbarium and plant systematics program at Ohio State, and he worked hard to obtain modern herbarium cabinets, hourly wages for student mounters, and more space. He also encouraged undergraduate and graduate students to study topics in plant systematics.

Ron had many research interests: aquatics, botanical history, conservation, floristics, nomenclature, phytogeography, and taxonomy. An important part of Ron's research, especially in the early years, was the flora of the Erie Islands in northern Ohio. The islands represented a good system to combine floristics with history of the islands. A key achievement was the publication with Thomas Duncan (a former OSU undergraduate) of the *Flora of the Erie Islands*, long delayed but finally brought into print in 2010. On the wet sandy beaches and abandoned limestone quarries in western Lake Erie, Ron discovered a new natural interspecific rush hybrid (between *Juncus alpinus* and *J. torreyi*), named for him as *Juncus ×stuckeyi* by his graduate student, Mark Reinking (1981).



*Ronald Stuckey at Marblehead Peninsula, Ottawa County, Ohio, on 15 September 1988, with the hybrid *Juncus ×stuckeyi*. Photograph by Jane L. Forsyth.*

Ron had an extremely retentive memory (a valuable tool for efficient historical research), and this is where he focused as his career matured. Nearly 49% of his 115 publications from 1962 to 1994 dealt with botanical history (Burk, 1994). His principal focus was on the early botany of the Ohio Territories, but he also included analyses of historical herbaria in the eastern states. He published several books and monographs on historical topics: William Starling Sullivant (Stuckey and Roberts, 1991); women botanists of Ohio (Stuckey, 1992); the collected papers of geologist Jane L. Forsyth (Stuckey, 2003a); E. Lucy Braun (Stuckey, 2001); and three books on Edwin Lincoln Moseley, the educator-naturalist at Bowling Green State University (Niederhofer and Stuckey, 1998; Stuckey, 2003b, 2005).

His other major publication category was phytogeography (21.7%), with many articles documenting the invasion of foreign aquatic and wetland plants and their establishment and migration throughout eastern North America. He used historical information from herbaria and older literature to explain the present distribution of aquatic species, such as in relation to the former Ohio canal system (Roberts and Stuckey, 1992). Ron retired in 1991 and was named Professor Emeritus, continuing to work actively while in good health.

Ron was a good teacher, who enjoyed using a personal approach with his students. He taught aquatic flowering plants on the main campus in Columbus and Stone Laboratory (1966–1991) to more than 500 students—more students than at any other university in the United States. He was very effective in identifying highly qualified undergraduates from his course in local flora, giving them workspace in the Herbarium and encouraging them to participate in collaborative research projects. Some of these students continued for M.S. degrees at Ohio State, and others departed for advanced work at other universities. He had two Ph.D. students (Robert Haynes and Richard Lowden). At the M.S. level he supervised 18 students on topics such as Ohio floristics, vegetational surveys, and phytogeography. In addition to his appointment in the Department of Botany, he had strong programmatic ties to the School of Environment and Natural Resources, and a number of his students obtained environmental positions within the state.

Ron's professional affiliations included memberships in the American Society of Plant Taxonomists; the Botanical Society of America, where he served as historian-archivist for nine years; the International

Society for Plant Taxonomy; the Native Plant Society of Northeastern Ohio; the Ohioana Library; and the Ohio Academy of Science, where he served as historian-archivist and President (1994). He gave a paper at the annual meeting of the Ohio Academy every year from 1964 to 2001. He was also a member of the Ohio Natural Areas and Preserves Association, the Southern Appalachian Botanical Club, the Columbus Natural History Society, and the Ohio Academy of Medical History (of which he served as president in 1981).

Because of Ron's many professional activities, he received several awards: the Ohio Academy of Science Centennial Award (1991); the Herbert Osborn Award from the Ohio Biological Survey (2002); and the Ohioana Book Award (2003) for his *Lost Stories, Yesterday and Today at Put-in-Bay* (Stuckey, 2003c). He was most proud of his 2010 induction into the Ohio Department of Natural Resources Hall of Fame for achievements in botanical conservation. In response to his large donation of historical botanical materials to Ohio State, the Ronald L. Stuckey Herbarium Archives were dedicated in June 2019 (Freudenstein and Stuessy, 2019).

As Ron aged, he suffered from bouts of depression that interfered with his work, but he always kept going, pushing to keep active and make contributions. Apart from botany, he continued to pursue his life-long interest in bluegrass music to the extent that he could. His long-term goal was to produce books on botanical history of the Ohio Valley and invasions of aquatic plants in the northeastern U.S., each of which would have summarized decades of research. Unfortunately, poor health intervened, and these large projects were not completed. Nonetheless, he continued botanical research and publication up to 2006,

having produced more than 12 books and over 200 research papers (including reviews and necrologies). In later years physical problems accumulated, which eventually led to his passing on 11 January 2022 at age 84. He was buried in Rock Creek Cemetery, Eden Township, north of Melmore, Ohio.

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## IN MEMORIAM

### LEONARD THIEN (1938–2021)



Students of floral evolution, plant ecology, karyology, and molecular systematics were much saddened by the loss of Professor Leonard B. Thien of Tulane University, Louisiana, on October 24, 2021 after a long illness. In 1991 Professor Thien became an elected Fellow of the American Association for the Advancement of Science for his studies in cytology and the pollination biology of what we now call basal or relictual angiosperms. While Len Thien maintained a lab at Tulane for almost 40 years his field studies took him from the American Midwest to the Hudson Bay region of Canada, Latin America, Madagascar, Australasia (New Caledonia, Australia and New Zealand) and China.

Len's origins were distinctly Midwestern as he was born in Breese, Illinois. He took his BS at Southern Illinois University. His Masters was completed at Washington University, St. Louis, and this allowed him to meet the staff and use the facilities at the Missouri Botanical Garden,

introducing him to the Neotropics. The NSF awarded him a Research Assistantship under then Curator Calaway Dodson (1928–2020). Len assisted Dodson on a field trip to Ecuador collecting orchids. It's obvious that Dodson appreciated Len's work because he named several new species after him, citing the young botanist as a "co-discoverer." This included *Stanophea × thienii*, now recognized as a naturally recurring hybrid. Len remained interested in orchids for the rest of his career, contributing to taxonomic revisions while he and his graduate students investigated novel insect-orchid interactions.

From Washington University Len went on to UCLA for his PhD, in the laboratory of Harlan Lewis (1919–2008). He graduated in 1968 and married his wife, Lorraine, in 1966. She was also a student at the university and survives him. He was hired quickly by the University of Wisconsin in Madison as an Assistant Professor of Botany. Len and Lorraine weren't keen on Madison. It was a place of student protests in the 1960s, leading to the arrival of the National Guard following the explosion of the Army Mat Research Lab so close to Len's office. However, during this period he completed his first piece of fieldwork, published in the *American Journal of Botany* (Thien, 1969). It remains a significant publication today (see below). Len discovered that the blunt-leaved orchid, *Platanthera (Habenaria) obtusata* was pollinated by female mosquitos in the genus *Aedes*. His field sites horrified Lorraine. Len worked alone in those deep Wisconsin bogs. You could vanish without a trace if you fell through the sphagnum mats. Incomplete records indicate that he joined the Botanical Society of America by 1970. More than 80 publications would follow.

Happier and successful experiences awaited Len when he joined the Biology Department at Tulane University in 1971. He was promoted



Photos Property of Dr. David White (note the pollinators, a fly and beetles)

to Associate in 1975 and Full Professor in 1981. The 1970s were very good to Len, as it was the decade of the birth of his son Ben and daughter Laura. His research developed during this period and he began using species of what we now think of as basal angiosperms (eumagnoliids and ANITA Group) as model systems to develop theories on the evolution of the first flowers. The refugium flora of the American south was generous and his first paper on the pollination of American *Magnolia* species also appeared in the *American Journal of Botany* (Thien, 1974). Over the following decades he and his students would go on to examine the reproductive biology of the native American species of *Liriodendron*, *Illicium*, and *Saururus*. Of course, there weren't enough relictual taxa in North America to keep him busy, which meant trips to tropical islands of the southwestern Pacific (Thien, 1980). His interest in the Winteraceae took him to New Guinea, New Caledonia, and finally to Madagascar. Len was adept at building consortiums of scientists with mutual interests who would work on different aspects of a project to produce a more holistic interpretation of the reproductive biology and phylogeny of obscure lineages (see Thien et al., 2003).

A most important feature of the Thien lab was his positive and often rapid approach to the incorporation of innovations and methods

unfamiliar to botanists. For example, to collect mosquitos carrying orchid pollinaria, he baited carbon dioxide traps with dry ice first described a few years earlier by DeFoliart and Morris (1967). As a Fellow of the Hormel Institute, a research center more devoted to biomedicine and meat chemistry, Len first worked on analyses of floral fragrances in the mid-'70s (Thien et al., 1975). He also kept up with biochemical analyses and fluorescence techniques to produce increasingly detailed and sophisticated interpretations of floral evolution. When the Biology Department split in two, the new Cell and Molecular Department became Len's, apart from the Ecology and Evolution Department. He learned genetic analyses to produce phylogenies attracting new colleagues from Japan and China. His research was supported by at least 11 state and national agencies. As more people came to Tulane to learn from him and write up their results, husband and wife repeatedly hosted and entertained graduate students and welcomed visiting scientists.

David White, his first graduate student, has great memories of being in the field with Len. Conversations were never dull. Len absolutely hated snakes, so common in Louisiana, but could never kill one unlike so many folks in the state. He was too gentle of a man. Many times, he even walked into the webs of the huge golden orb spider as it tends to spin

at eye level. For Len, his swamps and study sites were places for “critter respect.” The pollinators of *I. floridanum* are small and not willing to have their photos taken. Focusing on the spectacular red flower meant meeting a copperhead snake flicking its tongue as the lens came into focus. It became a special bonding moment between Len and David remembered long after publication (Thien et al., 1983).

With the subdivision in departments, Len’s lectures broadened. His courses in ecology gave way to molecular biology with a lab. However, Len’s passion was to teach nature’s wonders out-of-doors. Jean Lafitte National Historical Park was only a 30-minute drive from campus and a favorite for class trips. Boat trips, though, could be a challenge. On about the first scouting trip for David’s research in another part of the state, during high tide in an old university boat driven by David, a sharp turn in the bayou was missed and the vessel ended up aground 30 m into the wire grass marsh. They were marooned for more than half an hour, close to dark in an age without cell phones. Finally, a second boat came along and there was no need to wave considering the extent of their predicament. “Boy, do we feel stupid,” Len said. “No worries,” said the rescuer in his broad Cajun accent, “It happens all the time.” Len said he loved that story as, 50 years later, David has never had a similar accident nor seen such a one after thousands of boat miles.

Len always gave one of his collaborators the impression he was looking forward to retirement. During one night in a hotel in the New Caledonian countryside (he and I were investigating the floral biology of *Amborella tirchopoda*; Thien et al., 2003) he said abruptly, “Do you know what to retire means, Peter? It’s a military term and means to retreat from the field.” A few years later, though, he showed his deep loyalty to Tulane after the

university reopened following Hurricane Katrina. The highways into New Orleans were still strewn with debris. He would call me and often sounded angry describing how often he had to change his tires to and from Tulane. However, his usually unflappable manner not only explains how he progressed so well under bad conditions but helps us understand why his projects were successful even when he worked in culturally distinct, and often politically unstable, parts of the world. This must explain why, in his last years at Tulane, Chinese colleagues found it so important to work with him on the Schisandraceae, allowing him to investigate that family in the ANITA group although it’s poorly represented in the American south.

Younger botanists may still wonder does it really matter what I publish in the long-term? It did in Len’s case. Let’s return to Thien (1969). Over 50 years later, a team of scientists published an extraordinary paper in the *Proceedings of the National Academy of Science* (Lahondere et al., 2020). Acknowledging the work of Leonard Thien, they returned to that little, green-flowered orchid and its mosquitos. *Platanthera obtusata* emits a nonanal-rich scent uncommon in other members of its genus. The nonanal attribute that balances levels of excitation and inhibition in one of the insect’s antennal lobes, and the same segment also warns the mosquito to avoid incoming fumes of DEET.

Len’s legacy teaches us that making a fresh discovery is laudable, but opening an intellectual window to both current colleagues and future scientists is better. This should always remind us that science is a torch race even when it takes a half a century to pass. Leonard Thien leaves a far more knowledgeable scientific world because of his passion to learn, teach, and complete research; a noble trifecta. We thank you for your gifts.

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—Peter Bernhardt, Research Associate, The Missouri Botanical Garden; and David White, Professor Emeritus, Loyola University



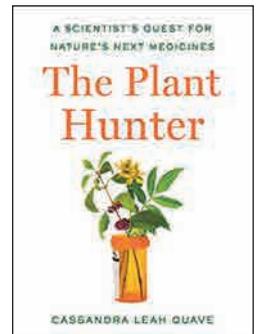
## ANNOUNCING! BOTANY 2022 PLENARY SPEAKER!



DR. CASSANDRA QUAVE

THE PLANT HUNTER

GET A PREVIEW & READ A REVIEW  
OF HER NEW BOOK ON PAGE 97



Plenary Lecture - Sunday, July 24 - 7:30 pm  
Book signing to follow



# MEMBERSHIP NEWS

## 2021 Gift Membership Drive Results and Drawing Winner

The 2021 Gift Membership Drive (October through December 2021) was a great success. We had a goal of 175 gift memberships, and the BSA community purchased 187—thank you!

You can purchase gift memberships at any time, including the new 3-year gift membership for both students and developing nations' colleagues.

Want to donate a gift membership to a student or developing nations' colleague instead? Simply put your own name and email in the recipient fields. Visit [www.crm.botany.org](http://www.crm.botany.org) to get started.



**Congratulations  
Summer Blanco  
2021 Gift Membership Drive  
Winner of Free Registration  
to Botany 2022!**

Summer (she/they) received their bachelor's degree in Biology with a Botany option from the California State Polytechnic University, Pomona. Following her undergraduate education, she took a position as a post-baccalaureate research assistant in the Biochemistry and Molecular Biology department at Michigan State University. Currently, they are pursuing their PhD in Plant Biology at the University of Georgia studying flower color polymorphism in Geranium.

Summer is excited to be coming to Anchorage in July!



**By Amelia Neely**

*BSA Membership &  
Communications  
Manager*

*E-mail: [ANeely@  
botany.org](mailto:ANeely@botany.org)*

## INTRODUCING BOTANY360: THE BSA COMMUNITY EVENT CALENDAR



We are excited to announce the launch of Botany360! Botany360 is a community event calendar that highlights events happening during the other 360 days outside of the Botany Conferences. The program was a direct result of the BSA strategic planning process, and the goal is to keep the BSA community connected and supported with a variety of workshops, webinars, and gatherings that will include professional development opportunities, discussion sessions, and networking events.

To access the calendar, go to <https://botany.org/calendar/display>.

If you are interested in adding an event to the Botany360 calendar, email [aneely@botany.org](mailto:aneely@botany.org).

## BSA AWARD OPPORTUNITIES

BSA is proud to provide over \$100,000 in award support each year. The following BSA Awards and Grants have a deadline in April–May 2022.

Visit the BSA Awards Homepage at <https://botany.org/home/awards.html> to see the complete awards schedule.

### April 1, 2022 Deadline

- Distinguished Fellow of the Botanical Society of America
- BSA Emerging Leader Award
- Jeanette Siron Pelton Award
- PLANTS Grants
- BSA Young Botanist Awards
- Charles Edwin Bessey Teaching Award

### April 15, 2022 Deadline

- Professional Members Travel Awards
- BSA Student and PostDoc Travel Awards
- Developing Nations Travel Awards
- PUI Faculty and Future Faculty Conference Awards
- Sectional Travel Awards (see full list on BSA awards page)

### May 15, 2022 Deadline

- BSA Impact Award

## DID YOU KNOW?

Do you want to know more about what the BSA has to offer you as a member? Each month a new BSA resource will be highlighted in the BSA *Membership Matters* newsletter in the “Did You know” section. Below are the first two resources. Visit [www.botany.org](http://www.botany.org) and browse the website to find even more great information.

Looking for a summer internship or a new full-time position? Did you know that BSA has a free jobs board at <https://jobs.botany.org/>? Each month in the *Membership Matters* Newsletter, we give you a sampling of what is on the board in the highlights section, but right now there are over 70 job positions posted! New positions are being posted regularly, so check back often!

Did you know that during the “Great Pivot of 2020” BSA created a resource page at [https://botany.org/home/resources/online\\_resources.html](https://botany.org/home/resources/online_resources.html) for teaching virtually? This webpage was updated throughout the pandemic with information as it became available. The page has recently been overhauled to reflect the current reality of increased in-person learning/teaching and highlights even more online resources for classrooms as well as the previous virtual teaching links.

Make sure to check out the Membership Matters eNewsletter for more great information, events, and news. Not receiving the eNewsletter? Email [aneely@botany.org](mailto:aneely@botany.org).



# BOOK REVIEWS

Double Helix of Phyllotaxis: Analysis of the Geometric Model of Plant Morphogenesis.....	88
Driven by Nature: A Personal Journey from Shanghai to Botany and Global Sustainability .....	90
Flora of North America North of Mexico Vol. 10 Magnoliophyta: Proteaceae to Elaeagnaceae.....	92
The Forgotten Botanist: Sara Plummer Lemmon's Life of Science and Art .....	93
Guide to the Vascular Flora of Buxton Woods, Dare County, North Carolina, U.S.A. Sida, Botanical Miscellany 54 .....	95
Presenting Science Concisely.....	96
The Plant Hunter: A Scientist's Quest for Nature's Next Medicines .....	97
Spices, Scents and Silk: Catalysts of World Trade.....	98
Stomata: How Plants Breathe: Topographic Perspectives in Selected Plant Families .....	100

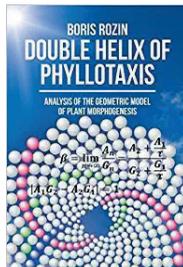
## Double Helix of Phyllotaxis: Analysis of the Geometric Model of Plant Morphogenesis

Boris Rozin

2020. ISBN: 978-1-62734-74808

\$39.95 (paperback); 182 pp.

Brown Walker Press / Universal Publishers, Inc.



Plant phyllotaxis has been of interest to botanists, mathematicians, gardeners, horticulturalists, and anyone who has marveled at the incredible symmetry and patterns displayed in the growth patterns of plants. How this remarkable symmetry develops and is maintained has fascinated biologists, mathematicians, physicists, and other scientists for hundreds, if not thousands, of years. Adler et al. (1997) reviewed the history of the study of phyllotaxis and divided it into three periods: an Ancient Period (from antiquity to the 14th century), a Modern Period (from the

15th century to 1970), and a Contemporary Period (from 1970 to today). Within these periods, Adler et al. observed that, within this history, there has been movement and progress between experimental-observational and theoretical-mathematical viewpoints of research. This book by Rozin is a contribution to the theoretical-mathematical analysis of phyllotaxis in which he develops the Double-Helix Model (DHM) of phyllotaxis.

Rozin opens with three short chapters (Introduction, Mathematical Foundations, and Phyllotaxis), which total 20 pages, to set the stage for the development of his DHM that he explores in Chapters 4–10, covering 100 pages. These are followed by three chapters (11–13) and six supporting appendices.

Being a botanist, with my strengths in taxonomy and morphology, I found the book weak in the discussion of the botanical aspect of phyllotaxis. Chapter 2 (9 pages) sets up the

mathematical foundations with a discussion of the golden ratio, recursive sequences (highlighting the Fibonacci sequence), then generalized recursive sequences, and spirals, which is a lot of material, in a short space, and important for the development of the DHM to follow. Chapter 3 reviews botanical phyllotaxis, concepts, and terminology, but is quite short (8 pages) and relies heavily on the work of Jean (1994). This chapter was too short with the concepts so tersely explained that I had to seek other papers for clarification and understanding. It provided the minimal foundation and did not discuss the wide variety of research on phyllotaxis that has occurred in the Contemporary Period. The author is a mathematician and so the weak botanical discussion is not surprising, but improving and strengthening this chapter would help the many potential readers not well versed in either the biological or mathematical aspects of phyllotaxis. I found myself needing a copy of Jean (1994) and acquiring papers cited by the author and many not cited as I perused recent literature on phyllotaxis. For example, Rozin very briefly mentions that the various arrangements of leaves on stems, from opposite to pinnate and other periodical patterns, are based in some form of fundamental phyllotaxis; unfortunately, he does not discuss this any further.

Chapter 4 sets the mathematical background for the DHM and is very short at 5 pages; consequently it is dense, but understandable and very interesting for mathematically inclined readers. Chapter 5 presents the Planar DHM on Archimedean Spirals and is very detailed covering 41 pages and mathematically dense, but with helpful diagrams and graphs. Chapter 6 covers Fibonacci Lattices on Planar non-Archimedean Spirals and so enlarges the scope of Chapter 5. Chapter 7 covers the Cylindrical D-H Model and so moves to the

application of the model to three dimensions, with colorful drawings and diagrams. Chapter 8, Phyllotactic Lattices with Rational Divergence Coefficient, expands the three-dimension aspect of the DHM. Chapter 9 then provides some discussion of the DHM assessing some strengths, weaknesses, and areas for further research. Chapters 8–10 provide observations about phyllotaxis, how it should be measured, and concluding remarks assessing the DHM.

A unique attribute of this book is the availability of 119 videos depicting the spirals, cylinders, and other structures and how changes in the parameters of equations or sets of equations change the structure and phyllotactic pattern. The author put in a great deal of work to develop these videos, and they are a great aid in enhancing understanding. I found the videos very enlightening, and they add a tremendous amount to the understanding of the equations. One video in particular, titled “Unified Morphogenesis of Spiral Phyllotaxis,” is remarkable in showing the growth of parastichies from an isolated shoot apical meristem and converting into a two-dimensional sunflower capitulum, then transitioning to a three-dimensional cylindrical pineapple, and finally expanding into a stem with leaves in spiral arrangement. These videos can be accessed on the author’s YouTube channel by searching for the book title and author.

The author provides a wealth of support for his DHM of phyllotaxis but does not discuss any other competing models and how the DHM may compare to them. In a recent review of Rozin’s book by Gielis (2021), he points out that Rozin has omitted accounting for the fact that the Fibonacci sequence of numbers is not rigidly adhered to in plants, and discussion of this natural variation is needed. The mathematics may be precise, but nature

is often not precise, as is frequently observed by biologists.

This book is a strong contribution to the theoretical-mathematical development of phyllotaxis, but it exclusively focused on the DHM. The book is tersely written, as often found in mathematically based books, and there are places where the flow of English is a bit awkward, but there are not many. Overall, the figures are very good, but in some cases the captions could be improved for better understanding. This is an excellent book for anyone interested in this particular model of phyllotaxis, but it is not a good overview of the wide field of the study of phyllotaxis or the various other models that have been proposed. Even with the problems noted above, it is a concise introduction to the theoretical-mathematical study of phyllotaxis and the DHM model and will provide the adventuresome reader with insight into the complexity of phyllotaxis and development. By working through this book and videos, I have gained a substantially greater knowledge and understanding of phyllotaxis. For mathematically inclined botanists and biologists, it is very interesting and I found a number of fascinating points to consider in thinking about plant morphology and plant development in general.

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—Richard Lis, California Department of Fish and Wildlife, Redding, California 96001

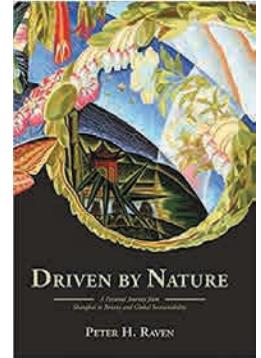
## Driven by Nature: A Personal Journey from Shanghai to Botany and Global Sustainability

Peter H. Raven

2021. ISBN-13: 978-1-935641-19-3

Cloth, US\$35.00. 359 pp.

Missouri Botanical Garden Press



Probably every botanist in the world knows something about Peter Raven: President Emeritus of the Missouri Botanical Garden (MoBot), member of the U.S. National Academy of Science, Past-President of the Botanical Society of America, author of popular introductory biology and introductory botany textbooks, and vocal and influential environmentalist. This is all true, and there are many more superlatives that could be included. But after reading Raven's autobiography, I have a much greater appreciation for the influences, both positive and negative, that drove his remarkable journey. In the preface he identifies three themes that provided life-long orientation: collecting, people, and self-motivation.

Kids collect things; Raven began with butterflies at age 8, then moved on to beetles and the Student Section of the California Academy of Sciences (CAS). At 10, CAS's botanist, Alice Eastwood, drew his attention to plants, and later her successor, John Thomas Howell, cultured his interest in collecting plants (two perfect examples of the effect of interested and enthusiastic mentors profoundly impacting the life of a young person). In 1950, at age 14, "a man named Stebbins" offered to provide Raven a ride to the Sierra Club Base Camp where he had a summer job. Raven asked if they could do some collecting along the way and, after he explained to Mr. Stebbins the process of collecting plants, he was assured

that Stebbins understood what this entailed and that it would not be a problem. They spent several days collecting together in the Sierras before Stebbins dropped Raven off for his summer job. Collecting continued to be an important component of his professional training, postdoctoral work, his first academic job at Stanford, and whenever possible during his tenure at Missouri Botanical Garden (MBG). His sabbatical year collecting in New Zealand is the focus of a full chapter in the middle of the book.

As illustrated by the above accounts, people and networking were important to the young Peter Raven and continue to be so. One of the most interesting parts of the book for me was simply to learn more about many of the botanists I have known, or known of, as Raven introduces them as part of his growing botanical social network throughout the book. And every time, from Edgar Anderson and Dan Axelrod, through Paul and Anne Ehrlich and Mildred Mathias, to E.O. Wilson and Wu Zhengyi, he gives credit to each for their accomplishments and their contributions to his own. Snapshots of colleagues and mentors are peppered throughout the book—a bit of visual botanical history from the mid-20th century to the present.

Raven has many accomplishments, so it is not surprising that throughout his life he has been a driven multi-botanical tasker. His success is being able to focus on big ideas while being inspirational, persistent, and

persuasive in convincing others to come along and be part of the big ideas. Whether it be the Flora of North America Project, building the international reputation of the MBG, inspiring the need for world resource conservation, or championing science and science education, Raven consistently surrounds himself with a network of individuals that pick up the details and fill in the missing links to make a project successful.

The 14 chapters divide roughly into four groups. Three chapters focus on his family history and early life. Three more focus on his preparation as an academic botanist, from an undergraduate to his first faculty position at Stanford. Four chapters describe his transition from an academic to an administrator and the transition of the MBG from a national to an international presence. The final four chapters champion the broader impacts of conservation, education, and science at the national and international levels. Raven is a good storyteller and his is a good story. Young and early-career botanists will be inspired by Raven's story, and many of us older ones will be surprised at some of the things we learn from reading it. All of us will enjoy the experience of learning more about Peter Raven.

—*Marshall D. Sundberg, Roe R. Cross Professor of Biology, Emporia State University, Emporia, Kansas*

**Flora of North America  
North of Mexico Vol. 10  
Magnoliophyta: Proteaceae  
to Elaeagnaceae**

Flora of North America Editorial  
Committee

2021. ISBN-13: 9780197576076

Hardcover, US\$95.00. 488 pp.

Oxford University Press



The latest volume in the Flora of North America series treats 454 species in 66 genera of 12 families. The families covered in this volume include the Proteaceae, Buxaceae, Gunneraceae, Haloragaceae, Combretaceae, Lythraceae, Onagraceae, Myrtaceae, Melastomataceae, Surianaceae, Polygalaceae, and Elaeagnaceae. The bulk of the volume (at 270 pages) is taken up by the Onagraceae. More than 25% of the species are illustrated with line drawings of excellent quality. I do wish the line drawings had labels underneath each illustrated plant part. For instance, the illustration for *Terminalia catappa* (Combretaceae) shows two flowers (one staminate, the other bisexual) that have differing lengths. But you wouldn't know which is which unless you looked very closely to see the style in the longer flower. I am not familiar with that species (or family), so it took me a bit to understand why there were two flowers in the illustration.

This volume is the same as previously published volumes regarding layout and book quality. Each family has the typical technical description followed by general information and a key to genera (if applicable). Each species description is accompanied by a distribution map with dots in states or provinces where the plant is found. Some species have longer descriptions than others, as has been seen in previous volumes, and some aren't as fully described as others (e.g., one species has seed size given but another species in the same

genus will not). I have found this type of omission to be an annoyance when trying to develop keys to a smaller group of species in a narrower geographic range. I always find it enjoyable to read species entries and learn the taxonomic history, uses, and other interesting facts. Thankfully, many of the difficult genera (e.g., *Myriophyllum*, *Oenothera*) have a lot of this extra information for most species, which is very helpful in understanding and identifying them.

I tried a handful of the keys and they all worked well. There were no glaring mistakes or inconsistencies. My largest complaint with this volume is the data quality for the range maps. *Ammannia robusta* (Lythraceae) and *Oenothera curtiflora* (Onagraceae) are each known to grow in Wisconsin. The former was first collected in 2000 and the latter in 2006. However, Wisconsin does not have a distribution dot on either of the respective species maps. The data for these specimens (with photos) have been available on the WisFlora website (<https://wisflora.herbarium.wisc.edu/index.php>; a portal for the consortium of Wisconsin herbaria) since at least 2006. Wisconsin has also been omitted from the range maps of other species in previous volumes of Flora of North America, and not just waifs and sporadic weeds but well-known native species, e.g., *Cardamine pratensis* (Brassicaceae). I understand that a work of this scope is difficult to make perfect, but when such a large repository of data is freely available, it seems odd that it would not have been incorporated into the present work. Especially when its data have also been added to other databases such as USDA Plants and The Biota of North America Program (BONAP).

Conversely, there are two species mapped as occurring in Wisconsin that, to my knowledge, do not grow here. *Ludwigia decurrens* (Onagraceae) and *Myriophyllum aquaticum* (Haloragaceae) are both mapped for the state, but I can find no specimens to corroborate this. I searched the Consortium of Midwest Herbaria, Consortium of Northern Great Plains Herbaria, and the Consortium of Northeastern Herbaria but could find no specimen records of either species. Strangely, BONAP shows *Ludwigia decurrens* in Walworth Co., Wisconsin but again, no specimen (that I can find) verifies this and the species is not even listed in *Flora of the Chicago Region* (Wilhelm and Rericha, 2017), which covers this area. The occurrence of *Ludwigia decurrens* in Wisconsin seems unlikely given its native range, but the possibility that *Myriophyllum aquaticum* has been found here is troubling. This species is prohibited by state law from being sold in Wisconsin and there is no record of it growing here. If a specimen exists to prove that a wild population is (or was) here, it would be nice to know where so it can be found and eradicated (if established). *Flora of North America* authors “are expected to have seen at least one specimen documenting each geographic unit record (except in rare cases when undoubted literature reports may be used)...” so this begs the question where these species’ specimens were seen. Again, I understand it is hard to keep any published volume of this scope perfect, but range data at this broad scale should be accurate.

Overall, this is another fine volume in this monumental series.

—John G. Zaborisky, Botany Department,  
University of Wisconsin – Madison, Madison,  
Wisconsin, USA; jzaborisky@wisc.edu

## The Forgotten Botanist: Sara Plummer Lemmon's Life of Science and Art

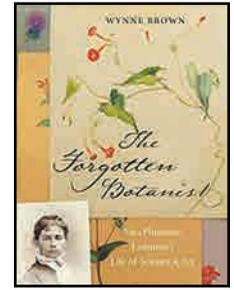
Wynne Brown

2021

ISBN-13: 978-1-4962-2281-7

\$27.95 (Paperback); 328 pp.

University of Nebraska Press



If I'm honest, I don't often enjoy biographies. I usually find them unnecessarily dense, sluggish, and hard to get through. Despite this, I chose to review Wynne Brown's *The Forgotten Botanist*, and in doing so, I feel like I won the lottery. I lived in Tucson, Arizona, for six years during my graduate work studying botany, ecology, and evolutionary biology in the shadow of Mt. Lemmon, and doing much of my field work there at the top of the mountain. As I read this book, I kept exclaiming, “How did I NOT KNOW about this fascinating woman?”

Sara Plummer Lemmon, the subject of this engaging biography, was in fact the Lemmon that Tucson's highest mountain was named after. Brown brings this 19th-century botanist alive in her recounting of a fascinating woman passionately dedicated to the study of plants. Brown benefits from a rich and deep mine of personal letters written by, to, and about Sara Plummer Lemmon, and Sara's lively voice shines through in the excerpts dotting the landscape of the book's pages.

Sara Plummer (I'll refer to her by her first name from here on, as the author does) left the East Coast in 1870 and traveled alone to California. She was 33 years old at the time, and having struggled with a number of serious illnesses, she moved west in the hopes of recovering her health. Rail travel was iffy, so she sailed south, crossed the isthmus of Panama, and then back north along the Pacific coast. Settling in Santa

Barbara, she quickly became integrated into society there and soon established the town's first public library, and for a while, running the library was Sara's primary occupation. However, she also became engaged in a community of inquisitive women interested in the natural world, and with them formed the area's first natural history association. In the company of these women, she learned how to identify and collect plants and create herbarium specimens, and her life's passion was born.

Six years later, Sara meets the love of her life, John Gill Lemmon, another avid botanist. They married in 1880 and lived 28 years together, by all accounts in very happy companionship and collaboration. They wrote books together, taught classes together, traveled and explored, collected plants, and presented at two World's Fairs together. This biography celebrates their relationship and how interwoven their work was. They collected plants throughout the southwest together, discovered new species together, wrote several books together, taught classes together, and from their letters, seemed happiest when they were at each other's side.

This book is peppered with interesting stories of a fascinating life; in these pages, you'll read stories of harboring refugees after the San Francisco earthquake, representing the botany of the West at two World's Fairs, lobbying for the golden poppy to be named state flower of California, ascending Mt. Shasta in hobnailed shoes to study pines, making donuts on an open fire and raising wild turkey chicks, hiding for 8 days in darkness in a cave with a crazy hermit miner, and so much more. You'll read about her connections with John Muir, Clara Barton, and Asa Gray, among others, and about her work in journalism, forest conservation, and women's suffrage.

Most importantly, Sara was a highly accomplished and respected botanist in her time, discovering (with J.G.) hundreds of new species of plants, collecting thousands of specimens documenting the floral diversity of the western states, and sharing her love of plants with others. She was also a talented artist and created beautiful illustrations of many of the plants they studied, and some of these are included in the book. Sadly, most of her artwork has been destroyed over the years, and little of it remains today.

Brown's book is full of engaging narrative, great storytelling, and evocative character development. Interspersed images of Sara's artwork and herbarium specimens, as well as photos of her and her husband complement the writing very effectively. Importantly, Brown does point out and acknowledge the ways in which Sara's actions and words were imbued with the racism and colonialism so prevalent in white American culture of the time. The structure of the work flows well and only rarely did I find the reading becoming dense or sluggish. The one thing I wished for that the book lacked was an index. Many times I find myself wanting to refer back to points or topics in the text; an index would have made this book a more useful historical account.

I highly recommend this book to anyone wanting to understand the contribution of women to the field of botany, but also to anyone who wants to read a fascinating and memorable tale of life as a botanist in the 19th century. Sara will come alive for you on these pages. Hopefully, her days of being a forgotten botanist may finally be in the past.

—Amy Boyd, Warren Wilson College

**Guide to the Vascular Flora of Buxton Woods, Dare County, North Carolina, U.S.A. Sida, Botanical Miscellany 54.**

Amanda L. Faucette, Alexander Krings, and David L. Lindbo 2020;

ISSN: 0883-1475;

ISBN-13: 978-1-889878-60-7

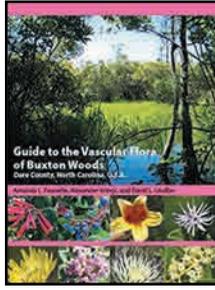
\$35.00 US, 236 pp.

Fort Worth: Botanical Research Institute of Texas Press

This is the fourth volume in the Illustrated Floras of North Carolina Project and follows the pattern of the other three issues. There are discussions of edaphic and climatic features; a treatment of plant communities with more than 270 color images, graphs, and charts. Among the 476 species documented by collecting and herbarium surveys, I was intrigued that the eastern mistletoe, *Phoradendron leucarpum*, is not included because it is frequent on trees in wetland sites along the coast.

The remainder of the book consists of keys to species and line drawings taken from Britton and Brown 1913. (I continue to believe the axiom that keys are made by people who don't need them for people who can't use them; the inclusion of good images is a propitiation for this shortcoming.)

Especially helpful are images of *Carex* achenes and perigynia. Likewise, images of grass spikelets, and details of Asteraceae flowers aid identification and pedagogical use of these challenging taxa. In field botany or even plant taxonomy classes, sedges and other graminoids often receive scant attention. The *Guide to the Vascular Flora of Buxton Woods* is everything you would want in a local flora. For me, it is a template for a planned future regional flora (sans keys).



It could be argued that limited funds and resources for botany could be more effectively used. On the other hand, is there a better way to raise local plant awareness than through authoritative and accessible works like this?

Buxton Woods includes threatened plant communities—a problem exacerbated with the continuing development of the Outer Banks as a tourist destination. Accordingly, this book deserves the attention of conservation-minded, natural history-oriented citizens, wildlife enthusiasts, urban planners, and educators of the region. It should be featured in local bookstores as well as gift shops at the many Outer Banks' tourist attractions.

While the work deals with a very restricted region, it will have application throughout much of the mid-Atlantic coastal area. The price is low for a publication of this quality, making it an ideal textbook or supplement resource for field botany courses.

The book is well edited and carefully proofread, and color reproduction—while not outstanding—is good. My copy of the book has distracting unevenness of print with half of some pages lighter than the other half.

The consortium producing these volumes, Herbarium of North Carolina State University and Botanical Research Institute of Texas, deserve kudos for their latest edition. I look forward to the next.

— *Lytton John Musselman, Blackwater Ecologic Preserve, Old Dominion University, Norfolk, Virginia 23529*

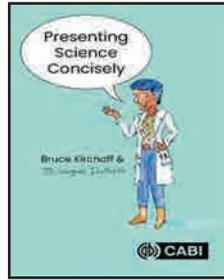
## Presenting Science Concisely

Bruce Kirchoff, illustrations by Jon Wagner

2021. ISBN-13: 9781789246995

Paperback \$30.00; 126 pp.

CAB International, Wallingford, UK



This book about communicating science is particularly directed toward biologists, not just botanists—but it is perhaps less useful for other disciplines, such as the physical sciences, where the culture may be somewhat different. Kirchoff, a plant morphologist and long-time active member of the Botanical Society of America, has long had interests in ancillary subjects, as demonstrated by his book *Emerson's Science of the Spirit: A Visual Interpretation of Emerson's Natural History of Intellect* (Kirchoff, 2009) and his involvement in educational and cognitive psychological theory to help in the production of keys and in the recognition of plants and their organs. I have sat through more than one painfully deficient scientific presentation with him and am not surprised that he would undertake this book and use his psychological interests to strengthen it.

The two cornerstones of the book are (1) the art of presenting science through storytelling and transforming the story into a play of three or more acts, and (2) a focus on knowing and reaching the author's audience. The book is primarily about presenting science orally and visually, although the principles are also relevant to writing scientific articles, as in organizing an introduction or discussion and in producing a title. The book is organized as concise chapters; Chapters 3–8 cover the different types of presentations, from three-minute (or “lightning”) talks, to elevator “pitches” of 15–90 seconds, to more traditional talks of 12 minutes or more, and finally to poster presentations. The principles

of narrative and audience are stressed in each presentation type. Kirchoff brings the lessons home by presenting examples from different biological disciplines and giving examples for the reader to examine and solve. Each chapter cites the relevant literature, some articles as recent as 2021. The chapters on posters are particularly useful, because they include a detailed discussion (and examples) of titles and bring in cognitive psychological principles, and EyeQuant technology to track visual movement on the poster. These two chapters by themselves are worth the price of the book.

The illustrations, created in color for the book by Jon Wagner, are at once whimsically humorous and totally to the point of the discussion in the text. I was especially taken by the illustration of hundreds of poster presentations ongoing in a vast convention center hall, showing the personal enthusiasm and conversations going on simultaneously.

I recommend this book to anyone who works as a biological scientist and presents research results to a variety of audiences (just about every reader of the *Plant Science Bulletin*). *Presenting Science Concisely* is published by CABI (Centre for Agriculture and Bioscience International), a global non-profit institute focused on sharing information in agriculture and the environment. The book is certainly relevant to their mission. It is a slim volume, perhaps a bit expensive for its size, but can also be purchased at reduced cost as an e-volume, PDF, or on Kindle.

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— *David Lee, Emeritus Professor, Florida International University, Miami, FL.*

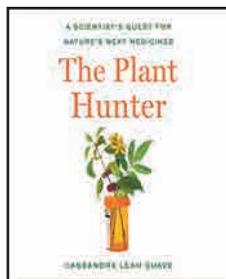
## The Plant Hunter: A Scientist's Quest for Nature's Next Medicines

Cassandra Leah Quave

2021. ISBN-13: 9781984879110

Paperback, US\$26.00; 384 pp.

Viking, New York City, New York, USA



Did you know that salicin within willow tree bark was used as a basis for the discovery and development of aspirin? Well, maybe so. However, you probably did not know that the resin from *Croton lechleri* was used to create an anti-diarrheal drug, or that miswak, a natural toothbrush, comes from the *Salvadora persica* plant, or that four billion people living in developing countries rely on medicinal plants as their primary form of medicine. In *The Plant Hunter*, Dr. Cassandra Quave, a leading medical ethnobotanist, regales readers with stories of her life and adventures to remote corners of the world to learn from traditional healers about medicinal plants so scientists can better understand the safety and efficacy of the plants that billions of people rely on for their medical care. This page-turning book is organized into three parts, with four chapters per part, as well as a detailed prologue, epilogue, and appendices with additional resources, scientific names, acronyms, and citations.

The book starts with a prologue that provides a brief history of antibiotics and ethnobotany. Dr. Quave also takes the time to introduce herself and explain that her drive to find medicinal plants to treat bacterial infections stems from her youth when she had to have her leg amputated and she faced a subsequent infection that led to a near-death experience. The prologue transitions to Part One, titled “Nature,” which focuses on the early part of Dr. Quave’s life. Chapter 1 sheds light on her parents, amputation, and love of the outdoors

and science, which led to her middle school science fair experiments, volunteering at a local hospital, and early college days at Emory University. A college trip to Peru in Chapters 2 and 3 takes the reader on an adventure where we meet the warm and caring Don Antonio, who teaches a young Cassandra about medicinal, cultural, and spiritual significance of many plants in the Amazon. Over time, young Cassandra learned about how, with the influence of western medicine, there was a lot of significant loss of Indigenous knowledge. Yet, western medicines were too expensive, so many people suffered and died from very treatable illnesses. Seeing this illness and death in person when shadowing Señor Vidal, a local doctor, convinced Cassandra that she wanted to be an ethnobotanist. Chapter 4 takes young Cassandra to Italy, where she worked with Dr. Pieroni to study ethnic Albanian folk-functional foods. While in Italy, she learned how to cook, treat spiritual ailments with elderberry and walnut, and solidified her stance on the importance of preserving traditional knowledge. She is also introduced to Marco, who would become her husband and companion.

Part Two, titled “Infection,” focuses on the transition from young Cassandra to Dr. Quave. Chapters 5 and 6 detail Cassandra’s graduate school years at Florida International University, education about botany, Latin, and phytochemistry, her marriage to Marco, the birth of her first child, her struggles being a mother and scientist, and more adventures in Italy where she conducted dissertation research looking at plants, such as chestnut, that can be used to treat dermatological issues. Chapter 7 focuses on the newly minted Dr. Quave’s transition from doctoral student to postdoc and from botany to microbiology and natural products chemistry. She details

her research with blackberries and the development of the PhytoTEK company with her colleague, Sahil Patel, which focuses on plant technology and traditional ecological knowledge. The eighth and last chapter in Part Two details Dr. Quave's move back to Emory University and her research into blackberries and chestnuts to target bacterial biofilms and toxins. She reflects on her transition from full-time lecturer to PI and director and curator of the herbarium, her adventures dumpster-diving for lab equipment for her new (to her) lab, and transition to joining the dermatology faculty and running three lab spaces.

Part Three, titled "Medicine," brings more adventure and concludes with Dr. Quave in the present day of the COVID-19 pandemic. Chapters 9 and 10 discuss her travel to biodiversity hotspots like the Mediterranean, where she was able ride a mule up to some Roman ruins to collect fragrant tree wormwood, and more about her research in Florida with yellow water lilies and the invasive, but medicinally important, Brazilian peppertree. She also discusses the importance of including and giving back to the communities that provide the traditional knowledge about medicinal plants. Chapters 11 and 12 take Dr. Quave on more adventures to Albania and the U.S. Capitol to bring the antibiotic resistance issue to the forefront of policymaking. The issue of antibiotic resistance is further discussed in the epilogue to drive home the point that "nature is all around us; it is within us... We must remember our place in the natural world and work with it to discover new ways for it to help us as we help it."

On the outside, this book seems like it could be a heavily scientific text focused on medicinal plants. In truth, this is the story, a memoir, of one very strong, persistent, and caring scientist

and ethnobotanist who shared the story of her life and research so others can learn more about antibiotic resistance and the importance of medicinal plants and traditional ecological knowledge. In addition to learning about the importance of blackberries, Brazilian peppertree, bacterial biofilms, biopiracy, and brews (and following the life and loves of Dr. Quave), readers also get a glimpse into some of the struggles faced by scientists who are mothers, women, and non-able-bodied. Dr. Quave often reflects on her struggles to be a scientist and mother, conduct fieldwork as an amputee, and address mansplaining, sexism, and academic bullying. As a scientist, I appreciated her honesty, vulnerability, and tips for stopping these inequities. In all, this book provides a little for everyone. Interested in medicinal plants, traditional knowledge, bacteria and antibiotic resistance, botanical collections, or inequities in science with a dash of adventure and romance on the side? If yes, then this book is for you.

– A.N. Schulz, *Department of Forestry, Mississippi State University, Starkville, Mississippi, USA*

### Spices, Scents and Silk: Catalysts of World Trade

James F. Hancock

2021. ISBN 978-1789249743

(hard cover) \$130, £95.00,

€110.00

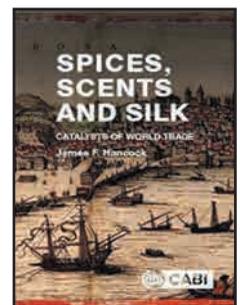
9781789249750 (paper) \$40,

£29.99, €35.00

ePDF 9781789249767; ePub

9781789249774

CABI, Oxfordshire, UK; Boston, MA



James Hancock, Professor Emeritus, Department of Horticulture, Michigan State University, pinpoints the world's leading spices used since antiquity as frankincense, myrrh, cinnamon, pepper, ginger, cloves, saffron, nutmeg, and mace. Hancock divided this broad subject into readable stand-alone

chapters, each with its own list of references, eliminating a need to search through a long alphabetical bibliography at the end of the book. Hancock acknowledged that he quotes freely from these cited authors, whose own words are eloquent.

Hancock traces the quest for profits from trade in spices, scents, and silks that motivated ancient peoples to explore the world in search of exotic luxuries from distant lands, while competing for long-distance trade dominance. Readers can travel in time, beginning with the earliest great civilizations served in the walls of four spherico-conical vessels excavated in 12th-13th-century layers at Dvin, Armenia, using gas chromatography combined with mass spectrometry (GC-MS). These vessels all contained trace levels of—Egypt, Sumer, and Harappa—along ancient Mediterranean trade routes, overland to the Land of Punt for incense, or spice depots of the Indian Ocean.

Transitions from the Golden Age of Byzantium to the eastern Roman Empire and the rise of Venice, led to medieval shifts in the balance of power. Portuguese discovery and conquest enabled the Portuguese to build an empire. After the Spanish built their empire, the Dutch and English conquered Southeast Asia.

The title of James Hancock's journey through history via trade in spices and scents was enticing. Having spent many weeks searching for further information about several topics included and omitted from this book, I discovered a tome with a similar title by Lawton and Wheeler (2004), which suggests lack of originality. Hancock acknowledges in his Preface that he “use[d] a blend of primary literature and historical fiction to produce what I believe is an expansive, sometimes amusing narrative.” Reading this volume alone, it would not be simple to separate fact from fabrication, to determine whether a construct is accurate. One source he cites, is

Secrets of Saffron by Willard (2002), a book of fiction. I would suggest that readers proceed with caution in accepting details without checking facts further. Studying the citations closely, it is dissatisfying to find that many are secondary sources and compilations.

It is also disappointing that the Index includes only a single mention about Armenian contributions, consisting of two sentences in connection with caravans along the silk route, although Armenia was mentioned on another page as an ancient source for horses and mules in world trade. Omitted are significant details about the Armenian trade at its zenith. Its vast commercial network was spread not only over the Levant but over Europe, India, and the Far East, centered at New Julfa, Isfahan, and Iran (Hussain, 2005; Mkrtchyan, 2005; Ranjbar and Manesh, 2016). Armenian settlements were found in all important trading and production centers, as well as on the transit points on all major routes. A substantial Armenian community was present in all ports of consequence.

Barnard et al. (2016) analyzed the organic residues of fat and oils, findings that they interpret as the remains of scented oils, suggesting the function of these vessels as containers for perfumes.

As I contemplate the implications presented by this book vis-à-vis trends in scholarship, within my own experience there have been several recent concerns noted about books reviewed in this *Bulletin* where I observed lack of academic rigor. It seems that there is weakness in the

Editorial process, leading me to question what direction science writing is taking. That said, there is plenty here to satisfy general readers with an interest in the global economics of the spice trade through history.

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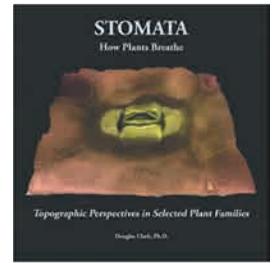
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— *Dorothea Bedigian, Research Associate, Missouri Botanical Garden, St. Louis, Missouri, USA*

**Stomata: How Plants Breathe: Topographic Perspectives in Selected Plant Families**

Douglas Clark  
2021. ISBN-13:  
9798757725406

Paperback, US\$44.99; 300 pp.  
Paedia Press, San Francisco, CA



As a fan of *Teaching Plant Anatomy* (Peterson et al., 2008) I was anxious to examine this new book by Clark. Unfortunately, I was disappointed. Nevertheless, there are some good aspects to highlight. The first 30 pages begins with an introductory-level description of the stomatal apparatus and reasons for studying stomata. Textbooks tend to focus only on water use efficiency, but the author also includes studies of climate change, plant classification, uptake of nutrients and chemical treatments, plant pathogens, and possible use in landscape plantings to reduce fire risk. The author then moves to preparing peels, epidermal shaving, and epidermal casts. This section is not very useful on its own (e. g., “There are many videos and written instructions for these methods available on the internet” [p. 4]). Much more useful is the section on microscopic image acquisition—stacking images and stereo stacked images to provide 3-D visualization. Even here, though, additional background information is necessary. For instance, to calculate the number of images required for a stack, it is necessary to establish known focal points above and below the stoma of interest. But you will have to go elsewhere to find the depth of field of the particular lens you want to use and how to set up Köhler Illumination. The latter is also necessary to calculate depth measurements for 3-D views.

The two short chapters on methods and results of in vivo studies were the most interesting. The author provides illustrated descriptions of how to construct a chamber that allows for testing of different gasses, different temperatures, and different wavelengths of light while examining the effects on living stomates. The results include data from two experiments using *Tradescantia spathacea*. The first plots change in “stomatal open area” (pore?) in response to changes in temperature, humidity, and CO<sub>2</sub> concentration over a 4-hour period. The second examines the effect of different light intensity and quality on the “stomal opening extent” over a 3-hour period. There are clear teaching and research applications for these techniques.

The majority of the book (pp. 30–295) provides “topographic perspectives [of 47 species] in selected plant families,” and it is here that I was most disappointed. Many of the images are very attractive and the 3-D images can be informative (if accompanied by a planar image with depths indicated). This was done only for *Arugula* ‘Astro’, *Dianthus* hybrid, *Echinopsis lageniformis*, *Ginkgo biloba*, and *Tradescantia spathacea*. For most of the other plates, the only labeling is a scale bar. At the beginning of this section the author provides an illustrated table of seven stomatal complex types, mostly taken from Metcalf and Chalk (1950), but Metcalf and Chalk presented this terminology in their 1979 second edition. The latter edition also includes a very useful set of well-labelled illustrations of a stomatal apparatus in both tranverse section and surface view. Interpretation of outer and inner ledges, the inner back cavity, outer ledge aperture, and actual pore (stoma) is all clearly demarcated. This is important because in the author’s table of stomatal density and stoma size in *Agave*, *Masdevallia*, and Peony, it is not clear if the

pore, the stomatal ledges, or the entire extant of the guard cells is presented for stoma size (or if this is even consistent between species?).

The references are useful and include one of the authors articles in *Microscopy Today* 24(4): 12-15. Two others are mentioned in the acknowledgements, *Microscopy Today* 27(1): 12-17 and 27(4): 18-23. These three articles contain the information that I found most useful in the text and I would recommend downloading them before deciding to purchase the book.

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# Plant Science Bulletin

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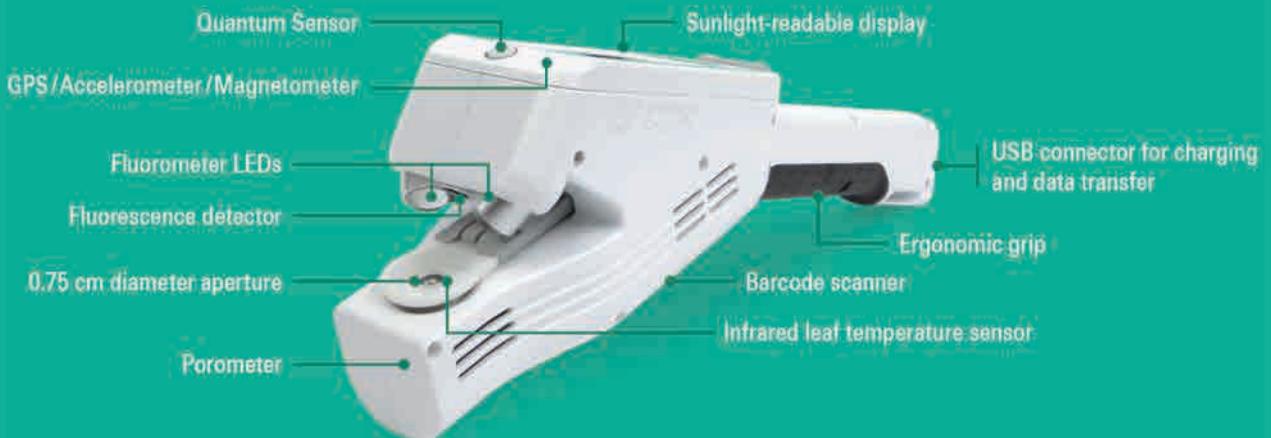
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