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In This Issue

FROM the EDITOR

Greetings,

Putting together this issue of *Plant Science Bulletin* has been bittersweet for me, as it is my last issue as editor-in-chief. Serving as *PSB* editor has been one of the highlights of my career and I speak more about this in a short question-and-answer segment on page 199. I am very proud of this issue, as it exemplifies my favorite kind of *PSB* issue by including a little bit of everything. We have timely articles that focus on pressing issues in botany, including one by Theresa Culley and colleagues that addresses the use of AI in BSA publications and one by Caroline Bose that discusses why and how botany can become more inclusive and accessible. You will also find reflections by the two winners of the 2024 BSA Public Policy Award who attended the AIBS Communication Boot Camp and Congressional Visits Day in D.C. to promote science and botany to legislators.

The highlight of this issue, for me, is a special feature on education in which several of our recent Charles E. Bessey Award winners share teaching philosophies and strategies. I was thrilled with the diversity of articles that I received in response to my invitations. I am also happy to include two final articles on the theme of science and art. Both articles look specifically at the role of art in paleobotany.

Thanks to you all for being readers of *Plant Science Bulletin*. I hope you enjoy this issue!

Sincerely,

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DR. SEAN GRAHAM

DR. CAROLINA SINISCALCHI

The Botanical Society of America is thrilled to announce that Dr. Sean Graham (University of British Columbia) will serve as the new Editor-in-Chief for the American Journal of Botany (*AJB*) and Dr. Carolina Siniscalchi (Mississippi State University) will serve as the new Editor-in-Chief of the Plant Science Bulletin (PSB) beginning in January 2025.

Both Drs. Graham and Siniscalchi bring to their new roles impressive credentials and strong commitments to Society publications. In concordance with the strategic goals of the BSA, they both are committed to diversity, equity, and inclusion as an essential practice in all aspects of science.

Dr. Graham is a Professor in the Department of Botany at the University of British Columbia, Vancouver, Canada, who has wide-ranging research interests in plant systematics and evolution, and in particular characterizing plant biodiversity from phylogenetic and phylogenomic perspectives. His interests have ranged from addressing challenging higher-order relationships—both across and within the major lineages of land plants—to more focused systematic studies of closely related taxa.

He has studied the molecular evolution of plant genes and genomes, and the evolution of plant sexual systems. He has strong ongoing research interests in monocots and mycoheterotrophic plants.

In addition to a full career as a professor and recent Head of the Botany Department at UBC (2016–2021), Dr. Graham has served BSA Publications for many years, including as an AJB Associate Editor (2008–2017 and 2019–2024), and as a guest co-editor on two AJB special issues ("Exploring the Potential of Angiosperms353, a Universal Toolkit for Flowering Plant Phylogenomics" in 2023; the Charles Darwin Bicentennial in 2009). He has also played a publications-related leadership role, as he was elected for two successive terms as the BSA Director-at-large, Publications. In this role he helped lead the transition of AJB and Applications in Plant Sciences from self-publishing to partnering with the commercial publisher Wiley. As a Director, he was also a BSA board member, and he advocated to the Board for the creation of the AJB Synthesis Prize for early-career researchers (ECRs). He has also served in multiple additional official and unofficial service roles, including on the BSA publications committee and the publication ethics subcommittee. He regularly assists the editorial team with analysis of the annual Journal Impact Factor and has strongly promoted the need to increase the number of review articles as a key tool to improve our impact more broadly. This insight helped lead to the creation of an AJB "Reviews Editor" role at the journal, and was part of the motivation to establish the AJB Synthesis Prize..

According to Dr. Graham, "I believe strongly in society-run scientific journals, which are motivated by science over profit. I therefore regularly publish some of my best research in *AJB*. I would like to find new ways to encourage others to do so, too."

Dr. Graham will begin his five-year term on January 1, 2025. He replaces the remarkable current Editor-in-Chief, Dr. Pamela Diggle, whose second five-year term concludes December 31, 2024. [See her outgoing thoughts elsewhere in this issue of the *PSB*.]

Dr. Siniscalchi is an Assistant Professor and Data Science Coordinator in the University Libraries at Mississippi State University. Her main areas of botanical research interest are the macroevolution of the nitrogen-fixation symbiosis in flowering plants and the systematics and evolution of the sunflower family. She also has expertise in data science, bioinformatics, and research data management. Her strong background in systematics research and current position in library science are a unique combination that will bring new ideas and directions to the *PSB*.

Dr. Siniscalchi received her bachelor's, master's, and doctoral degrees from the Universidade de São Paulo, Brazil. She has been a member of the BSA since 2017, when she first moved to the United States, and has attended five Botany meetings since then. She was a member of the APPS Reviewing Board from 2020 to 2022, served on the BSA International Affairs Committee (2019–2021), and is currently the Secretary/Treasurer for the Southeastern Section.

Dr. Siniscalchi's vision for the *PSB* is that it will reflect the wide array of interests and diversity of BSA's membership. "I want BSA members to see the bulletin as not only the place where they receive information from the society, but also as the place where they can talk about themes that are not strictly scientific but that are inherently part of being a botanist (and I use botanist here in the widest sense: not only as academics, but every person that has plants as the center focus of their work or hobby)," she says.

Dr. Siniscalchi will begin her five-year term on January 1, 2025. She replaces the amazing current Editor-in-Chief, Dr. Mackenzie Taylor, whose second five-year term concludes December 31, 2024. [See her outgoing thoughts elsewhere in this issue of the PSB.]

Ten Years of *Plant Science Bulletin*: An Exit Interview with Editor-in-Chief Mackenzie Taylor

What first drew you to take on the role of editor-in-chief of the *Plant Science Bulletin*?

I was interested in serving as the editor-in-chief of *PSB* because I believe strongly in its role as a resource for the botanical community. I have always loved the variety of articles in the *PSB* and the fact that it celebrates the achievements of BSA members. I think, at its best, it builds community within the BSA and provides a place for important discussions to occur outside of annual meetings.

Additionally, I wanted to provide a positive experience for others who wished to publish in *PSB*, especially for people rather new to publishing. My first publication was in *PSB* (Johnson et al., 2004), and I valued the experience of getting to work with collaborators and publish an article as an undergraduate. Marsh Sundberg, who was *PSB* editor at the time, made this a very positive experience and I hoped to pass this along to others.

What were your goals as editor-in-chief?

During my time as editor, I have had three primary goals for the *PSB*. The first has been to provide a platform for members and friends of the BSA to share ideas and knowledge in the realms of education, public policy, public outreach, and history. I consider the *PSB* to be the publication of record for the BSA in matters outside of scientific research. I believe that its pages should provide a snapshot of the environment in which botanical research and education is taking place, both for contemporary readers and for posterity.

The *PSB* team and I have accomplished this by inviting many of the people who have given addresses to the Society or led workshops, either at the Botany meetings or through the Botany360 program, to prepare written articles so that they might reach a broader audience. Some of our most thought-provoking pieces have come from these contributions. I have also encouraged our Public Policy Committee to keep the Society updated on matters such as funding for plant science research and relevant bills that come before Congress. When I started as editor, I felt strongly that the *PSB* could play a larger role in promoting and facilitating science advocacy. I think we made gains in this area.

My second goal was to provide resources for the botanical community, especially as they related to goal number one. During my 10 years, *PSB* has published articles with practical strategies and tips for preparing articles for publication, avoiding predatory publishing, submitting successful NSF grants, applying for Fulbright awards, conducting field work, improving scientific presentation skills, and moderating scientific sessions at conferences, among many other topics. *PSB* authors have contributed to the debate on issues such as plant awareness disparity and whether standardized tests should be used in admissions. We have continued to publish articles that present strategies for teaching in the classroom and laboratory, as well as for public outreach. Further, we created a section just for students. The student representatives share information and resources for student members and highlight the accomplishments of those members. I hope that *PSB* readers have found these articles to be useful. They continue to be available in the *PSB* archives.

My third goal was to elevate as many individual voices in the *PSB* as possible and provide a platform for many perspectives. There is always room for improvement in this area, but we have made a significant effort to engage with the broad botany community. For example, our recent special issues on Art and Botany included an open call for articles; the response was tremendous, including from authors who had never published in *PSB* before. In another example, we asked the larger community, including on social media, for articles about dealing with the pandemic that stimulated many thoughtful responses.

How has the direction of the *PSB* evolved over the past 10 years?

Over the last 70 years, *PSB* has been continually evolving to fit the needs of the BSA. During some periods it has included more articles and essays and in others, it has been more of a newsletter used for disseminating news and announcements. Over the last 10 years, we have continued a trend to reduce the emphasis on news and announcements, mostly because these are more easily and quickly disseminated via the email newsletters. In turn, I have made a deliberate effort to increase the number of peer-reviewed articles in each issue. My goal was always one or two articles per issue and most of the time we accomplished this. I also wanted to diversify the type of articles published in *PSB* so that we were serving as much of the botanical community as possible.

We decided when I became editor that we would continue to emphasize the print version as most of our readers indicated that they preferred that format. Near the start of my first term, we revamped the look of the *PSB* and created a new logo that I absolutely love. Ten years on, much has changed in the publishing landscape and the new editorial team will have to decide if it is time to transition to online-only publication or if there are new and better ways to reach readers. Whatever it looks like in the future, I am hopeful that *PSB* will only grow in value to BSA members.

What do you consider your most rewarding accomplishments in your role with the *PSB*?

There are many things I'm proud of regarding my role as *PSB* editor. One of the most rewarding to me personally was the series of issues that came out in 2020–2021. These were very volatile times, with universities and businesses shut down due to the COVID-19 pandemic and the United States in the middle of significant political upheaval. I conceptualized and coordinated both the Summer and Fall 2020 issues from my dining room table because Creighton's campus was closed. Despite this, I believe these issues are some of the most important in *PSB*'s history. We provided tips for educators and researchers who were working with reduced resources and attempted to provide a record of these times for future reference through special features (Taylor, 2020; Min et al., 2020; Gaynor and Valdez, 2020). We also did our best to lift up the voices of people who had timely and meaningful ideas to share about inclusion and equity in botany (e.g., Dewsbury, 2020; Leonard, 2020; Asai, 2021) and have made featuring these perspectives an ongoing priority. I am also very proud of the Art in the Botanical Sciences special issues that were published in Fall 2023 and Spring 2024, although the hardest work was done by the guest editors for these issues and the authors. These were very well received and demonstrate the unique ability *PSB* has to cross disciplinary lines.

What has been the best part of serving as *PSB* editor?

Serving as the editor of *Plant Science Bulletin* has truly been a highlight of my career. I have found great joy in thinking about what topics members of the Society would be interested in and then working with Richard Hund to figure out how to best feature that in *PSB*. The best part has been getting to interact with people I might not otherwise have had a reason to get to know, including our wonderful authors, section contributors, and article reviewers, as well as our book reviewers and the publishers who provide books for review.

Do you have any last thoughts?

It takes a team to create the *PSB*, so I want to thank everyone who has contributed to the *Bulletin* during the last 10 years, whether as an author, contributor, reviewer, or book reviewer. I especially want to recognize all the student representatives and policy committee chairs who have prepared sections for each issue as a part of their service in that role, as well as Catrina Adams and Jennifer Hartley for preparing our regular feature on Science Education. Truly, *Plant Science Bulletin* does not exist without those of you who contribute your time and energy to *PSB*. Thank you to Amy McPherson and to the BSA Publications Committee for helping to develop procedures and sharing thoughtful ideas. Special thanks to Johanne Stogran for compiling and formatting each issue. She does an incredible job making the *PSB* look fantastic in print and ISSU format. Finally, it has been an absolute joy to work with Richard Hund, *PSB* managing editor. I know that the *PSB* issue will be in the capable hands of Carolina Siniscalchi, and I am excited to see what she does to move the *Bulletin* forward.

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An Exit Interview with *American Journal of Botany* Editor-in-Chief Pamela Diggle After a Decade of Service

What first drew you to take on the role of *AJB* Editor-in-Chief?

One (perhaps glib) answer is that Carol Goodwillie asked me to!! She was the BSA's Director-at-Large for Publications and chairing the search committee. She was passing through my neighborhood and dropped by to discuss the possibility. I have vivid (very positive) memories of the occasion. We went for a long walk and talked at great length about the possibilities for the position. The other, more heartfelt, answer is that I had always been (and continue to be!) a strong supporter of the BSA and had participated in many aspects of its governance; I saw the editorship as an important opportunity to continue serving the society and botany. The *American Journal of Botany* also is of great significance to me personally. *AJB* was the first journal I subscribed to as a beginning graduate student, and I read the articles avidly. The growing row of issues, then bound in bright yellow card stock, arranged on my bookshelf, gave me a sense of belonging and professionalism. My first research paper was published in *AJB*. I also knew that *AJB* has been equally important in the careers of botanists across the country and internationally. So, as soon as Carol raised the possibility, I got very excited by the prospect and immediately began to consider what I might (aim to) do as Editor-in-Chief.

What were your goals as Editor-in-Chief?

I looked back at some of the documents I submitted with my application for the position and this sentence stood out: "The primary challenge faced by the *AMERICAN JOURNAL OF BOTANY* is the same challenge faced by the publications of all scientific societies: How will the Journal maintain relevance in this rapidly evolving world of diverse outlets for dissemination of science?" This is as true today as it was 10 years ago, and I continue to keep my focus on this challenge. One of my goals as incoming EiC was to increase the breadth of research areas included in the journal and to expand the geographic, institutional, and demographic diversity of authors and editors. To this end, I aimed to increase all aspects of diversity among the board of Associate Editors. *AJB* currently has 64 Associate Editors, 49% of whom are women, and who are in institutions from Argentina (1), Austria (1), China (2), Colombia (1), Denmark (1), France (2), Germany (4), India (1), Israel (1), Korea (1), Mexico (3), Netherlands (1), New Zealand (1), North America (39), South Africa (1), Spain (2), and Sweden (1). The diversity of authors is more difficult to gauge, but we will begin to track self-reported demographic data next year and will be able to keep tabs on how we're doing. I also aimed to "have the pulse of the readership"; to understand how readers and authors discovered articles, and what new and exciting research was on the horizon. I began to implement this immediately by holding a series of listening sessions (online and at Botany conferences) with botanists from a broad range of disciplines and career stages to understand how best to serve our community. These listening sessions have now been formalized as the ECAB (Early Career Advisory Board), which consists of advanced graduate students and post-docs who provide input and suggestions through regular meetings. I also wanted to bring new readers and authors to the journal by introducing a "News and Views" section in each issue of the journal that includes non-technical summaries of research papers ("Highlights"), brief essays on new areas of research ("On The Nature of Things," now a regular feature of most issues), and a diversity of opinion pieces and commentaries. Also, as a result of a plan hatched during a 2-day strategy retreat, *AJB* now features regular review articles. I thank incoming EiC Sean Graham, who was at that meeting, for presenting a compelling argument for a reviews section in *AJB*. And I am so very grateful to Jannice Friedman for taking on the enormous task of getting this feature off the ground successfully and serving as Reviews Editor for over two years, and to the current Reviews Editor, Kasey Barton, for carrying on this important work with grace and enthusiasm.

How has the direction of *AJB* evolved over the past 10 years?

Both *AJB* and the scholarly publishing industry in general have undergone tremendous change over the last decade. The year I started, 2015, marked a full century of *AJB* publication and in all of that time, it had been self-published. Library subscriptions largely supported the journal and, critically, other activities of the BSA. In acknowledgment of changing financial models and challenges of competition among scientific journals for diminishing resources in library budgets, *AJB*, in 2017, entered into a partnership with Wiley and is now in a second five-year contract. We joined with Wiley at a time when they had a strong stable of Society journal partners, and we benefit from their scholarly publishing expertise and economies of scale. With Wiley we have been better able to adapt to the strong push in STEM toward Open Access, which offers great advantages but also tremendous financial challenges—for both authors and Societies. Major changes in *AJB*'s distribution have also occurred. In 2015, *AJB* was provided to members electronically and/or, by request, as a hard copy of each issue. Printing of the journal was discontinued in 2019, and now all access is electronic. The ability to promote and share links to articles to a vast international community of botanical enthusiasts was greatly expanded as social media exploded over the past decade. As the social media landscape has grown more complex, *AJB*, along with the BSA, is emphasizing more diverse, and less divisive, platforms. One thing that hasn't changed is our careful copy editing, and the care and attention to detail that the *AJB* staff bring to each article and to our authors.

I want to emphasize, that although publishing has undergone dramatic transformations and many new features have been added to the Journal, *AJB* is a Botanical Society of America publication, and as EiC, I have kept the mission to serve the society and to publish "peer-reviewed, innovative, significant research of interest to a wide audience of scientists in all areas of plant biology" in mind with every decision that we've made.

What do you consider your most rewarding accomplishments in your role with *AJB?*

I would like to highlight my efforts to increase *AJB*'s inclusivity. As noted above, one of my goals as EiC has been to increase the diversity (in all of its multiple meanings) of authors, readers, and editors. To further this goal, all Special Themed Issues now include an open call for proposals for articles to be included in the issue. Early-career and other underrepresented groups of authors are especially encouraged to participate. And, last year we ran an open call for Associate Editors. This initial call drew a gratifying array of applicants from across the globe who were interested in serving botanical research generally and the journal specifically. The demographics of the BSA and of science and society at large are changing rapidly and that should be reflected in our journal. Moreover, encompassing a broad and diverse range of perspectives and approaches is imperative for addressing the pressing issues of global climate change.

What has been the best part of serving as *AJB* editor?

Serving as the Editor-in-Chief of *AJB* has been one of the most gratifying and rewarding experiences of my career. *AJB* is so much more than a journal. It is a community of exceedingly talented people working selflessly to advance botanical sciences and to support botanical scientists. We all know that, despite our best efforts as authors, it is the rare paper that is not improved during the peer-review process. I have had the pleasure of watching this "evolutionary process" as reviewers and Associate Editors take the time from their already over-scheduled days to carefully read and comment—some even going so far as to suggest new analyses, and provide code and all! The result is inevitably a stronger/clearer paper with greater impact. We receive many notes from authors about the positive experience they had at *AJB*. I'm grateful for the generous work of all the many people involved, past and present, in the *American Journal of Botany*. *AJB*'s Associate Editors continually amaze me. They bring such knowledge and insight to the papers they handle, and each of them is dedicated to the success of the journal. And then, there are the multitude of reviewers who cannot be thanked enough for their contributions. A special thanks goes to the amazing *AJB* Managing Editor, Amy McPherson, who has very much been my partner over the past decade (and the leader in understanding the rapid changes to the publishing industry). It has also been my pleasure to work with the equally amazing Production Editor, Richard Hund, who handles all the "behind the scenes" complexities that turn your manuscripts into published papers. (And who gleefully smuggled chips and beer into the Botany meeting venue for our first several information-gathering sessions.) Talented Content Editor Staci Nole-Wilson (and past Content Editors Sophia Balcomb and Marian Chau), among other things, skillfully ensures that your papers have all of the vital sections and are ready publish. And, most especially, I thank all of you who have contributed to the success of the journal by sending your research papers to the journal!

The Development of BSA's Comprehensive AI Policy for Its Academic Journals

In today's society, artificial intelligence (AI) is rapidly advancing and expanding through all aspects of our lives. The release of ChatGPT in November of 2022 made AI accessible to anyone with a computer and an internet connection. After the explosion of interest and activity that followed, AI now has the potential to radically change our world as we know it. According to a recent Oxford University Press poll (Anderson, 2024), researchers across scientific disciplines today are increasingly using AI tools, but also have extensive misgivings about AI technology. For example, 76% of researchers globally currently use some form of AI in their research (e.g., chatbot, machine translations, AI-powered search engines and research tools), but only 8% trust the AI companies not to use their own data without permission, and 25% are concerned about AI reducing the need for critical thinking skills in science (Anderson, 2024). Most recently, publishers Taylor & Francis and Wiley agreed to sell access to academic content to certain tech companies for training AI models, causing concern among the scientific community.

AI itself is a broad term that refers generally to non-human (machine) intelligence (De Waard, 2023), but AI can be adapted and used for specific purposes (Zhou, 2023). Underlying many AI tools are large language models (LLMs), which are trained on large amounts of existing text data or visual and sound recordings to decipher written human language and create media. LLMs are most useful for translation, summarizing existing text, and generating requested content such as Q&A. Generative AI tools such as ChatGPT use these LLMs with additional training to then create original content such as text, images, code, and even videos or music. AI can also be used in a process known as "inference" to draw conclusions from new data without depending upon only past examples.

By Theresa M. Culley[1,11*], Irene Cobo-Simón[2*], Robert L. Baker[3], Aaron S. David[4], Matthew A. Gitzendanner[5], Matthew S. Olson[6], Tilottama Roy[7], William N. Weaver[8], Pamela Diggle[9], and Briana Gross[10]

[1] *Department of Biological Sciences, University of Cincinnati, OH*
[2] *Institute of Forest Sciences (ICIFOR-INIA, CSIC), Madrid (Spain); Associate Editor of* APPS
[3] *National Park Service, Fort Collins, CO; Associate Editor of* APPS
[4] *Archbold Biological Station, Venus, FL; Associate Editor of* AJB
[5] *Department of Biology, University of Florida, FL*
[6] *Department of Biological Sciences, Texas Tech University, TX*
[7] *Department of Biology, Missouri Western State University, MO*
[8] *Department of Ecology and Evolutionary Biology, University of Michigan, MI*
[9] *Department of Ecology & Evolutionary Biology, University of Connecticut, CT; Editor-in-Chief of* AJB
[10] *Swenson College of Engineering and Science, University of Minnesota-Duluth, MN; Editor-in-Chief of* APPS
[11]*Corresponding author:* theresa.culley@uc.edu
**Joint first authors*

Generative AI tools are already impacting multiple fields of scientific research and the publication of scientific articles. Generative AI tools include a wide variety of technologies, such as natural language processing (NPL), which underlies generative pre-trained transformer (GPT) models, and image generation and editing. These tools can be used in writing to suggest text, correct grammar or spelling, or match a particular style of a scientific journal. AI tools are also extremely useful for data analysis; they can process large amounts of data with accuracy and speed, and identify patterns and information difficult to detect with traditional methods. AI can be used to generate code, automate repetitive tasks, and simulate experimental conditions. When used in these ways, AI has the exciting potential to propel science forward in ways we can only imagine today; however, its use also raises important ethical and practical considerations. Present-day AI-generated content can sometimes include incorrect, out-of-date, or nonexistent citations, or contain repetitive or inappropriate language, reflecting the biases/inaccuracies of the data on which the tools have been trained. AI tools can be used to manipulate images and may plagiarize existing text, but this technology can also be used to detect such actions with ever-increasing accuracy. For example, publishers such as Elsevier, Springer, and Wiley now use their own in-house AI tools to check for AI usage in submitted manuscripts to ensure integrity of their publications.

Recognizing the necessity of addressing the use of AI in the publication process, the Botanical Society of America (BSA) formed an ad hoc committee in fall 2023 to develop a policy regarding use of AI in its publications (*American Journal of Botany, Applications in Plant Sciences,* and *Plant Science Bulletin*). Committee members consisted of researchers selected from a special call for participants, BSA editorial staff (managing editors, production staff, associate/reviewing editors, and editors-in-chief), and the BSA Director-at-Large for Publications. This committee was charged to discuss generative AI tools as they apply to publishing and to then develop guidelines, policies, and best practices for authors, reviewers, and editors of BSA journals. The committee specifically focused on the following three categories:

1. Defining how authors may or may not use AI when writing text, including how to properly acknowledge AI tools (if allowed in any circumstance)
2. Describing how AI tools can be used for generating code as a potentially acceptable use
3. Deciding how reviewers may or may not use AI in their reviews

The committee met several times during the following months as individual workgroups focused on drafting sample language for each point above, and then as the full group to fine-tune the language. This AI policy established guidelines to promote responsible and ethical use of AI in scientific publications—aiming to harness the potential of AI while safeguarding the integrity of scientific research. The AI policy was then added to the Author Guidelines for all BSA journals and released publicly in spring 2024, with required disclosure of AI use on the author and reviewer submission forms. As AI continues to evolve, ongoing dialogue and adaptation of these policies will be crucial to ensuring that the BSA community remains at the forefront of innovation and ethical practice.

The purpose of this article is to describe the key points considered by our ad hoc committee during our discussions, namely: (1) how other journals and publishers have addressed AI to date, (2) current opportunities and challenges of AI tools, and (3) a summary of our committee discussion that resulted in the final BSA AI policy.

CURRENT STATUS OF AI IN PUBLISHING

Here we review as of April 2024 the current guidelines and policies of the top six academic publishers, as identified by Scholarly Publishers Indicators 2022 (https://spi.csic.es/), on the use of AI generated content (AIGC):

- Cambridge University Press
  https://authorservices.wiley.com/ethics-guidelines/index.html
- Elsevier
  https://www.elsevier.com/about/policies-and-standards/the-use-of-generative-ai-and-ai-assisted-technologies-in-writing-for-elsevier
- Oxford University Press
  https://academic.oup.com/pages/authoring/books/author-use-of-artificial-intelligence
- Taylor & Francis
  https://asset.routledge.com/rt-files/AUTHOR/Guidelines/Manuscript+preparation+guide.pdf
- Springer
  https://www.springer.com/gp/editorial-policies/artificial-intelligence--ai-/25428500
- Wiley-Blackwell
  https://authorservices.wiley.com/ethics-guidelines/index.html

All publishers consider the use of AI an ethical issue. For example, Oxford University Press states, "AI must be consistent with the Press's mission and the values inherent in our publishing, with all that this entails in terms of quality, integrity, and trust." All six publishers agree that AI is a tool that simulates human intelligence, but is not an intelligent entity in itself. Consequently, none of the publishers allow a statement of authorship by any AI-based tool (such as ChatGPT) in scientific articles. This is consistent with the 2023 statement from the Committee On Publication Ethics (COPE; https://publicationethics.org/cope-position-statements/ai-author), which states that AI tools cannot perform the role of an author of a work, nor therefore, appear in the list of authors of a work. As non-legal entities, AI tools cannot take responsibility for the ethical and legal aspects of the submitted work. Furthermore, Wiley and Elsevier point out the difference between the use of AI to make original intellectual contributions (without human direction)—which is not allowed—versus assistance in the preparation of scientific articles—which is allowed. Both publishers also point out the need for the authors to supervise the content generated by the AI tools. All publishers (except Oxford) state that authors are ultimately responsible for their manuscript content regardless of whether AI was used.

All publishers also agree that the use of AI to generate content must be transparent and correctly referenced, as required with any other tool. Any use of AI must be disclosed in the cover letter to the editor upon manuscript submission and/or in the Methods or Acknowledgments section of a manuscript. This is also consistent with COPE's position statement on AI tools. Elsevier, Cambridge, and Taylor & Francis all state that the use of AI tools must comply with editorial policies on authorship and principles of publishing ethics (also mentioned in COPE's position statement). Cambridge also emphasizes its anti-plagiarism policy, pointing out that any content generated by other authors and coming from AI-based tools must be cited and referenced in an appropriate and transparent manner.

There is a lack of consensus regarding the generation or modification of images through AI tools. Elsevier and Springer consider AI-generated figures separately from the generation of other types of content such as text, and prohibit it, with few exceptions. While Elsevier does not provide any explanation for this policy, Springer supports their policy by stating that legal issues relating to AI-generated images and videos remain broadly unresolved; consequently, Springer is unable to permit its use for publication. In contrast, Oxford evaluates AI-generated images in a similar way to the generation of other types of content (e.g., text, code), allowing it as long as it meets the criteria of transparency and is cited correctly. The remaining publishers do not consider the use of AI to generate and/or modify images separately in their Author Instructions; therefore, it is understood that they consider images along with generation of content in general. This is also in line with COPE's position statement on authorship and AI tools, which considers AI-generated images similarly to other AI-generated content (text, graphical elements, data collection, and analysis) and allows it as long as authors are transparent in disclosing within the article how the AI tool was used and which tool was used. Authors are also considered fully responsible for any AI-generated content, including all of its ethical aspects.

Several publishers have also developed policies concerning the use of AI in the review process. Springer stresses transparency in the use of AI tools during the peer-review process, requiring reviewers to declare any use of AI in their peer-review report. Springer notes that this technology still has considerable limitations (e.g., as described below, such as outdated information). Furthermore, Springer also explicitly prohibits reviewers from uploading any manuscript content into generative AI tools because manuscript text may contain sensitive or proprietary information. Both Elsevier and Springer note the rapid advancement of AI tools and therefore the need to regularly review their AI-related policies and guidelines.

More recently, publishers Taylor & Francis and Wiley separately gave licensing rights to AI companies for their repository of past publications (Dutton, 2024); Oxford University Press and Cambridge University Press are now forming partnerships as well (Wood, 2024). Taylor & Francis' $10 million deal with Microsoft is expected to assist their development of Copilot, Microsoft's AI assistant. Wiley's partnership with at least two undisclosed companies was reportedly worth $23 million and $21 million; in return, Wiley provides access to its published material to train LLMs by using book content and small pieces of individual articles, and to make a narrow range of articles specific to a topic available for use in inference. At this point, it is unknown whether authors will even know if their publication has been used. Except for a few publishers, authors are not able to opt-out of having their material used in this way, which has created much consternation for many authors (Authors Guild, 2024). In the case of Wiley, the company has established guiding principles for AI technology and partnerships (https://www.wiley.com/en-us/terms-of-use/ai-principles).

OPPORTUNITIES OF AI TECHNOLOGY

Artificial intelligence and LLMs offer many new and exciting opportunities for researchers not only to enhance their science, but also to promote communication through the publication process (Buriak et al., 2023). One of the most common uses of AI by authors is as a "personal copy editor" to improve the quality and clarity of the language in their manuscript, polishing text created by the author. When used properly, these tools are not dissimilar to automatic spell checkers and grammar checkers. Even Microsoft Editor is now promoted as an AI-powered service. The popular Grammarly tool also boasts of an AI communication assistant to help authors pinpoint areas of weakness, such as typos, missing punctuation, or commonly confused words. The premium version of Grammarly is advertised as using AI to adjust the tone, rewrite full sentences, and generate text for over 1000 different AI prompts in manuscripts and even email. Other AI-based editing and rewriting tools include Wordtune (for rewriting, shortening, or expanding content), WordRake (which edits for brevity or simplicity), Writefull (helping to write and paraphrase scientific text), and LanguageTool (a grammar checker specialized for multilingual writers). More grammar checker and rewriting tools will undoubtedly be released in the future, especially as generative AI and the machine learning on which it relies continue to improve.

Such personal copy editors powered by AI may be especially helpful for multilingual authors for whom English might not be their primary language, particularly when submitting to an English-only journal. Some authors already upload their own text into ChatGPT and then review the rewording, grammar, or punctuation suggestions to enhance the clarity of their papers. ChatGPT can be used for any language within its repertoire, which now includes at least 50 languages, with more being added to make this tool increasingly accessible and useful. Currently, some AI-suggested text may still be scientifically nonsensical or inaccurate, so a careful eye is required before accepting and incorporating any recommendations (see below). However, with continued training, future renditions of AI tools will likely overcome these problems.

AI tools can also be used by researchers to explore the literature when first embarking on a new topic, and to identify suitable references for their manuscript. When asked to provide peer-reviewed papers on a specific topic, ChatGPT provides a short list of usually five papers, but can be prompted to retrieve more. As with all AI-generated results, the papers may or may not relate to the topic and need to be reviewed further. Recent papers are usually excluded from the list, as dates of retrieved papers reflect when the AI was initially trained. For example, ChatGPT-4 Turbo released in November 2023 can only identify literature published up to April 2023. Other AI-powered platforms such as scholarcy (https://www.scholarcy.com/) help authors quickly summarize and organize articles applicable to their own research, increasing the efficiency with which researchers can search the literature.

As more authors use generative AI for polishing existing text, there are multiple downstream benefits. First, the overall written quality of manuscripts submitted to journals may increase, making it easier for editors to ascertain if a manuscript is appropriate for the journal and should be sent out for external review. A well-written manuscript is more likely to be perceived favorably by reviewers, who can focus on the scientific content rather than distractions of misspellings, grammatical errors, confusing sentence construction, and general disorganization. Such a manuscript will also reduce the amount of copy editing and time required for conversion into a publication-quality article, increasing the efficiency of the publication process.

For several years, publishers and editorial staff have been using their own AI tools to detect plagiarism and image manipulation, and to find appropriate reviewers for submitted manuscripts. BSA journals commonly use CrossRef's Similarity Check to review manuscripts for potential plagiarism. AI-powered platforms such as Proofig or imagetwin can also be used by editors and publishers to detect image manipulation. Publishers are now piloting AI to detect submitted papers generated from "papermills"—groups of individuals or an organization generating similar papers and submitting them fraudulently to multiple journals for financial gain. Editors can use AI to analyze a submitted manuscript's relevance to a journal, verify the identity of an author, and detect irregular publishing patterns by authors that may indicate fraud (e.g., a mathematician submitting papers to a medical journal). In a time where there are increasing numbers of predatory journals (Culley, 2018), AI can also be used to check the quality of references cited within an article. Publishers are also beginning to use AI tools to flag machine-generated content, especially when text may be translated into one language and then converted back in an effort to avoid detection (such as "big data" in English translated to "data grande" in Spanish and back to "greater data"). In a time when finding appropriate reviewers willing to read a submission is critical to the peer-review process, publishers are now using AI tools to locate suitable reviewers or to identify conflicts of interest (e.g., a proposed reviewer recently co-authoring a paper with the author) instead of a handling editor spending their own time to track down this information. In summary, incorporating AI tools to assist editors and publishers can greatly decrease the amount of time spent per manuscript, while enhancing the quality of the review and publication process.

Finally, when properly trained, AI technology can also be used to effectively conduct science. For example, AI-based models can be used to synthesize vast quantities of data that would otherwise require multiple people and many hours of labor. Such synthesis also minimizes the chance of mistakes being made and enhances consistency of any particular process. The power of AI can also be harnessed to identify patterns and relationships within large data sets that would otherwise be difficult and time consuming to detect. For example, LLMs can now be used to interpret text in digitized images of herbarium specimen labels (Weaver and Smith, 2023; Weaver et al., 2023). Another example is the revolutionary and recently developed AI program AlphaFold 3, which is able to predict the structure and interactions of proteins with other molecules such as DNA and RNA with unprecedented precision and accuracy (Abramson et al., 2024). AI can also be used as an additional overlay to identify any information that otherwise would regularly go undetected. Finally, AI can check code or even generate code within an experiment that would take a human many hours to create. In summary, the advantages of using AI within the scientific process itself are many, provided of course that all results are supervised and checked by the researcher themselves.

CHALLENGES OF AI TECHNOLOGY

While AI poses exciting and innovative opportunities, it is not without serious concerns and challenges in the publication process, particularly when used incorrectly. Many of these concerns can be avoided by treating AI as a tool to assist human decisions and by recognizing the inherent limitations of AI, most of which reflect the underlying machine-learning and training technology.

On the most basic level, AI technology can be prone to inherent errors such as incorrect, nonsensical, or blatantly false output (Davis, 2023). Citations may be incorrect, incomplete, or outdated because the AI tool is limited by its most recent training date. AI can also be weak at judging whether an unusual outcome is "spurious, anomalous or groundbreaking" (Buriak et al., 2023). Even the ability to detect a typical outcome will depend solely on the data provided to the tool during its training—hence the strength of any current AI tool will always be temporally and contextually limited. AI-generated tools are also known for sometimes creating shallow and superficial text with a superfluous tone. There are now detectors that can be used to identify such AI-generated text, such as Turnitin, TraceGPT, Hive, and GPTZero, but their effectiveness, accuracy, and cost can vary (Walters, 2023). In addition, inadvertent errors could occur if generative AI incorporates phrases that are not in the author's native language that may have an alternative meaning in another language that is not understood by the author (e.g., "background research" vs. "doing research in the background"). Finally, while AI can be effective at summarizing past studies (assuming it is able to detect all relevant content), the technology at the current time is still unable to look forward in time and provide a critical assessment of a topic and articulate next steps. These types of errors are especially concerning if readers assume AI-generated text is of human origin (Buriak et al., 2023). Such inaccurate information would also be very worrisome if it escapes detection by reviewers and is then published in a peer-reviewed journal, earning a scientific stamp of approval. In short, current AI technology is limited because it lacks human intuition and the ability to detect nuances and to conclusively project into the future.

Another major concern with the use of AI technology in the publication process involves confidentiality. When reviewers are asked to read a submission for a peer-reviewed journal, they must agree to confidentiality and not share the author's work or ideas. However, confidentiality could be violated if a reviewer uses generative AI to compose their written review by uploading part or all of the submitted manuscript into an AI tool. Although this is now starting to change, some popular AI tools may still incorporate text that has been entered into the search window in the subsequent training of its tool or technology, such that the same text or idea could potentially be suggested by the tool to another user in response to a related query. A potential solution is the use of private generative AI tools within individual laboratories in which training data are kept in-house; however, even a private generative AI tool may suffer from many of the same challenges outlined above. Using a private tool to generate a brief summary of the manuscript, as typically presented at the top of a formal review, could be helpful though, provided the platform is used with human oversight.

AI tools may also express inherent biases based on the algorithm and training data used to create the tool. Such bias can be sexist, racist, or even political, depending on what content was used in the initial training. For example, ChatGPT replicated gender bias when asked to construct recommendation letters for males (which used nouns such as "expert" and "integrity" and adjectives like "respectful" and "reputable") and females (emphasizing "beauty" or "delight" and who were "stunning" and "emotional") (Wan et al., 2023). In another example where ChatGPT was asked to create a crime drama, researchers used four-word prompts, only one of which changed (either "black" or "white"), to explore ChatGPT's potential implicit bias (Piers, 2024). Motoki et al. (2023) also found that ChatGPT exhibits left-leaning political tendencies, such as towards Democrats in the United States, the Workers' Party in Brazil, and the Labour Party in the United Kingdom. The reason for these biases is that many LLMs use data from the internet for their training, which largely reflects historical stereotypes and perspectives already present online. Thus, if left unchecked, the use of ChatGPT and other LLMs could inadvertently amplify existing and historical information on the internet and social media.

DEVELOPMENT OF THE BSA POLICY ON AI TECHNOLOGY

Our ad hoc committee met several times in 2023 and 2024 to discuss the ethical use of AI in the publishing process. We examined every aspect of the development of a research project: initial conceptualization, data collection, integration and analysis, interpretation and presentation of data, and writing the manuscript. Going into these discussions, many of our committee members were initially skeptical of using AI in the publication process due to its inherent limitations (see above) and the possibility of authors using it unscrupulously to fabricate text. In fact, several of us started the conversation thinking about excluding all elements of AI from the publication process but, as explained below, eventually we changed our minds. Ultimately, we agreed that there was no part of the scientific process for which AI should be banned because it has the potential to help in every aspect, if used appropriately. We recognized that there is no AI tool that is inherently beneficial or detrimental; it depends on how a given tool is used and the extent to which the user is aware of each tool's limitations. AI has the potential to make research more thorough by uncovering additional information beyond an author's immediate knowledge. Thus, we agreed that the development of guidelines for authors and reviewers for the publication process is key to taking advantage of this novel and promising technology, while avoiding its potential drawbacks.

We also recognized that the AI field is rapidly advancing with constantly evolving tools such that what we perceive today as cutting-edge may quickly become routine in the months and years to come. The AI of tomorrow will likely be different from the AI of today because machine learning algorithms and technology are rapidly improving. Consequently, our committee understood that any AI publication policy developed now will need to be revisited and modified in the future as AI technology changes.

CONSIDERATIONS FOR AUTHOR GUIDELINES

We all agreed at the onset that AI cannot be an author because a non-human entity cannot take responsibility for a paper. There must be human oversight of any AI assistance; it is imperative for authors to take full responsibility for any inclusion of AI-generated material in their research studies and manuscripts. Just as before AI was available, we trust authors to adhere to ethical standards while conducting their studies and writing their manuscripts. However, we also recognize that guidance and specific policy are necessary to prevent any intentional or inadvertent violations within the new AI landscape. Just as it is critical to specify when AI is *not* allowed, it is also important to spell out any approved uses of AI tools. We largely agreed with what publishers have already been doing: AI tools can enhance the quality of a manuscript in terms of grammar and sentence structure if it is used to polish an author's own words. AI can expand the information available to authors in the literature and locate otherwise difficult-to-find sources, and it can be used to help initially develop a research idea. If AI is used in any part of the paper, the reviewer should also be aware and take the time to confirm the accuracy and any potential biases of any AI-based information in the article. AI should never be used in isolation to produce text without human oversight or input.

We discussed whether the use of AI should be acknowledged in a manuscript through in-text citations or in the acknowledgments section, or if it only needs to be reported through the journal submission portal. These discussions focused on the question of who benefits from knowing that AI was used, and why they need to know. For uses related to improving the author's original writing, acknowledging AI software seemed unnecessary, and akin to acknowledging ubiquitous tools such as spell check within Microsoft Word. However, when the AI software was a critical component of the research, such as for image analysis, we deemed it necessary to acknowledge the AI software and version. Finally, because these are still early days for generative AI, we decided to include a question in the submission portal about AI use to better understand how often researchers incorporate AI in their manuscripts. This information would be used only for data collection and would not be passed on to the reviewers or editors.

We also considered the use of AI in code development. We determined that using AI tools to derive code is no different than adapting R code found online for a user's specific purpose. However, while AI could be helpful in identifying holes or inconsistencies in a researcher's code, it should not be used in stress-testing that code. We eventually agreed that AI-generated code can be used, provided that the authors acknowledge the AI assistance and detail its usage in the Methods section. An acknowledgment in the Methods section suffices if the AI was used for writing functions, adding documentation, or refactoring code for clarity. For example:

> *We used OpenAI's ChatGPT-4o to generate the initial implementation of the data processing function and to add inline documentation for improved readability.*

These tasks are comparable to assistance gained through Google searches or consulting Stackoverflow, where authors remain responsible for the accuracy and correctness of the code. However, a detailed explanation of AI usage is required when AI is used to automate analyses, such as performing statistical analyses on tabular data (see https://help.openai.com/en/articles/8437071-data-analysis-with-chatgpt). For instance:

> *We used OpenAI's ChatGPT-4o data analysis tool (gpt-4o-2024-05-13) to perform statistical analyses on our dataset, including generating summary statistics and visualizations. The AI tool›s methodology and output were reviewed and validated by the authors to ensure accuracy.*

In this example, the AI tool must be cited in a way that ensures the reproducibility of results because the AI significantly contributed to the analysis.

CONSIDERATIONS FOR REVIEWER GUIDELINES

Our committee also considered the use of AI in the review process. We decided that it does not help the journal or authors when the reviewer extensively uses AI to write their full review. The point of having peer reviewers is to obtain the researcher's own unique expertise, which any AI tool would lack. To abide by an AI program's usage guidelines (such as for ChatGPT), reviewers should not input the manuscript or any part of it into a public AI tool because this would also be a breach of confidentiality. However, reviewers could potentially improve the spelling and grammar of their own written review using an AI tool, akin to a grammar or spell checker.

Based on these conversations, our ad-hoc committee created AI policy for BSA journals as shown in the following box.

General Author Guidelines

Use of artificial intelligence and large language models (generative AI):

Generative AI programs, such as ChatGPT, are widely accessible and commonly adopted across various scientific domains. When employing generative AI in scientific work, writing, or figure generation, it is crucial for authors to be aware that unintended content may arise, necessitating careful oversight. Authors must assume full responsibility for content produced by generative AI programs before incorporating it into the submitted manuscript.

Authors are requested to cite the use of generative AI when appropriate. For example, if generative AI is employed as an integral part of the methodology, it should be cited in the Methods section, specifying the manner of use, program, and version. The use of AI to address editing and proofreading does not require acknowledgement in the manuscript. Please see Wiley's Best Practice Guidelines on Research Integrity and Publishing Ethics (https://authorservices.wiley.com/ethics-guidelines/index.html) for more information.

For Reviewers:

At (*AJB/APPS/PSB*), we highly value the professional expertise of peer reviewers to improve manuscripts published by the journal. Artificial intelligence (AI), including large language models or generative AI such as ChatGPT, is not allowed in the reviewing process. Uploading any author-submitted text, including the manuscript, abstract, or title, into an AI platform is considered a violation of confidentiality. The only exception is using AI as a tool to edit or proofread the language of a reviewer's own work.

Regarding Software and Code:

AI coding assistants have become increasingly powerful and commonplace. However, authors must be vigilant about the quality and accuracy of the generated code and take full responsibility for the results. Furthermore, authors who choose to use AI coding assistants are encouraged to take full advantage of their capabilities to generate tests, write documentation, and create robust, user-friendly, functional programs that can be more easily maintained and repurposed. In cases where AI is an integral part of the methods of the study, the authors should cite the program within the Methods section.

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SPECIAL SECTION

Honoring the Tradition of Botany Education in the *Plant Science Bulletin:*

A COLLECTION OF ARTICLES BY CHARLES E. BESSEY TEACHING AWARD WINNERS

As I started to near the end of my tenure as Editor-in-Chief of *Plant Science Bulletin*, I thought a lot about what I wanted my last issue to include. One of my favorite parts of being editor has been exploring the archives and reading the words of contributors over the past 70 years. A prevalent theme that has run through the *PSB* since the beginning has been botanical education. In fact, the very first article, printed on page one of the January 1955 issue, is an essay by the chair of the Education Committee, Sydney S. Greenfield. In his essay, Greenfield declares that Plant Science Bulletin will serve as a platform for discussions about education in plant science.

> "The Committee on Education of The Botanical Society of America has been studying means whereby it might effectively promote greater appreciation and proper development of plant science in the colleges, as well as the education of the general public as to the importance of plants and their study to man. It will require nationwide discussion among botanists of educational and other problems. with a view towards development and formulation of professional policies, and plans for coordinated constructive action.
>
> Until now, a major obstacle to cooperative analysis and attempts to solve our common problems has been the lack of an appropriate medium for intra-professional discussions, and in this regard, the establishment of Plant Science Bulletin may well presage a new era for professional botany in this country." (Greenfield, 1955)

By Mackenzie Taylor
Editor-in-Chief, Plant Science Bulletin

The early editions of *Plant Science Bulletin* are particularly rife with essays examining teaching philosophies and practices and setting out strategies for connecting with students, administrators, and the general public. I have found many of these articles, such as those by Palmquist (1956), Fuller (1957), and Stern (1971) to be especially impactful and I keep Palmquist's Ten Commandments for the Teaching Botanist posted on my office door. The need for dialogue on educational themes, of course, endures and *PSB* contributors have continued to both debate educational ideals and share practical classroom activities (e.g., Wandersee and Schussler, 2001; Carter, 2004; Keller and Bordelon, 2022). I have used a variation of the Market Botany lab in my own botany course many times (Martine, 2011), and I am thrilled to have been able to feature many education-focused articles during my time as editor (e.g., Doust, 2016; Sundberg, 2016; Goodwillie and Jolls, 2018; Montgomery and Farrah, 2021; Parsley, 2021; and many others). In my last issue of *Plant Science Bulletin*, I wanted to showcase and further this long tradition.

It seemed obvious to me that this special feature could also provide a platform for some of our Charles E. Bessey Teaching Award winners. Fortuitously, many of these winners were already preparing talks for the symposium "Bessey's Legacy: Enthusiasm and Innovation in Botanical Instruction," moderated by Ben Montgomery and Rachel Jabaily at Botany 2024, and were willing to adapt these presentations into print essays. I reached out to other past winners, as well, and almost everyone graciously accepted my invitation.

In my request, I asked only that contributors write about an issue of their choice having to do with teaching in botany. I suggested that articles could be a reflection on personal teaching philosophy, observations on the state of botany education, or a call to action for change. I'm pleased to say that the articles in this collection cover all of this and more. I found these articles to be inspiring and thought provoking and to provide a snapshot of the challenges and rewards of teaching botany in first quarter or so of the 21st century. I firmly believe that Charles Bessey, as well as Sydney Greenfield, Edward Palmquist, and the other botany educators who have graced the pages of *Plant Science Bulletin*, would be thrilled to see that the members of the Botanical Society of America continue a strong a tradition of thoughtful and reflective teaching.

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Four Things I Learned from 30 Years of Teaching (That You Probably Already Know)

By Cynthia S. Jones

Department of Ecology and Evolutionary Biology, U 3043, University of Connecticut, Storrs CT 06250 USA

The Botanical Society of America is replete with excellent teachers. Why? Because *botanists have to be good teachers*! The inherent bias against plants in the United States virtually ensures that most students, at least until very recently, take their first plant class in college because it satisfies a requirement. A good teacher erodes plant bias, ideally recruiting more than a few students to the "plant side." What we do as college teachers is incredibly important to ensuring the future of our academic discipline, and there is no better evidence than the *BSA Membership Matters* survey (Figure 1) from June 2022. The majority responding discovered their passion for botany as undergraduates. I know I did.

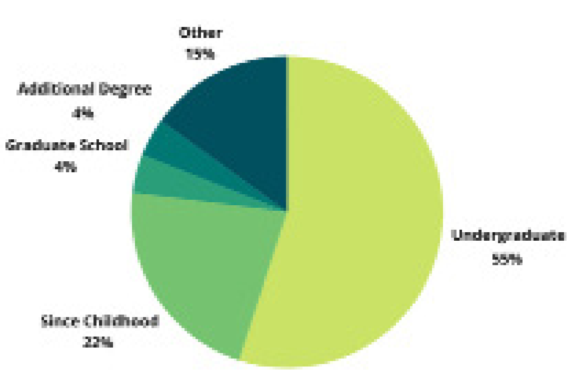

Figure 1. *Survey responses to the question "At what point did you choose botany as a focus of your career or interest?" June 2022, BSA newsletter, Membership Matters.*

When I first started teaching at UConn, I developed two upper division courses. One was Plant Anatomy, which was already "on the books," and the second was a course I called "Plant Developmental Morphology" based on the principles Don Kaplan taught at Berkeley (Kaplan, 2022). My approach to teaching was exactly what I had experienced as an undergrad and graduate student: a lecture/lab format where I gave the lecture, and a graduate student teaching assistant taught the lab. Lectures involved chalkboards and switching between projecting Kodachrome images and an overhead projector. Lecture exams were structured in a short-answer format, primarily based on comparisons, descriptions, and definitions. Lab exams were based on moving from station to station every two minutes or so, largely focused on recognition of features.

I was not an early devotee of PowerPoint lectures, but three features eventually swayed me: I wouldn't have to spend an hour before each lecture pulling and organizing slides, I could incorporate new images much more easily, and finally, I would save myself the hassle of switching between overheads and Kodachrome slides. Initially, my PowerPoint slides consisted of only images and graphs, but I soon discovered that using the chalkboard for the rest was awkward because when the projection screen was down, it covered the center of the chalk board. It wasn't long before I began to put the words and drawings I would have written on the board into the PowerPoint lectures. Grabbing images directly from the internet also meant I could quickly incorporate new material without finding the original books and papers to photocopy for overheads. A win-win for me!

Within two years, my evaluation scores declined, students seemed to sleep more in class, and they left the lab earlier and earlier.

My realization that I was no longer providing students with a course that most of them valued led to some soul searching. For me it was a question of self-respect—if I was going be in the classroom (which was part of my job, after all), then I wanted to do what I could to make it go as well as possible. I'm not a funny person by nature, so I knew better than to try to motivate an audience with humor; nor am/was I brilliant enough to captivate students just by talking without much prep. My approach was to present a course focused on content that was as clear as I could make it and by building a story line that flowed so one bit of information led to another. For me, plant development was the obvious thread, so both of my courses began with embryos and the plant body grew from there.

All this soul searching resulted in two insights: (1) I'm introverted enough that although I loved teaching, I never really "enjoyed" giving lectures—I learned to do it well eventually—but what I loved were the students' "ah ha" moments in the lab, and (2) I was drawn to teaching because of the plants. I had to figure out how to let the plants lead. I decided to try to restructure my courses around Don Kaplan's mantra "Ask the Organism."

1. Ask the organism

In 2017, my then PhD student Dr. Kerri Mocko, who had been my TA for several semesters, graduated. Before she left for her post-doc, I was able to pay her as an adjunct for one semester and together, we overhauled Plant Anatomy into what we called Plant Structural Diversity.

1. First, we created a "studio" time slot. We changed the schedule from one three-hour lab to two two-hour labs per week, with the lab scheduled to directly follow the "lecture," resulting in two three-hour time blocks.
2. We emphasized at the beginning of class that we were teaching a "skills" course, not a course that required memorization, but at the same time stressing the importance of the vocabulary. We told students the first day that by the end of the course, we expected them to be researchers, in that they should be able to make a hand-section of any vegetative organ on most plants and explain to someone else its internal structure and function of cells. Exams would be based on interpreting material they had never seen before, or interpreting something they had seen during the course, but from a different perspective.
3. We revised every lecture ("content delivery") so that it emphasized structure, function, and evolution together (e.g., a simplified phylogenetic approach to wood structure was followed immediately by ecological wood anatomy).
4. We reorganized the lab manual so that rather than being written in paragraph form (because students didn't seem to read carefully enough to figure out what they should see), the text was largely structured in bullet points with open boxes where they should draw specific features. Consequently, the important parts of what they should take away from each unit were abundantly clear.
5. We carefully matched the lecture and lab material in short time units, so that one of us would present content (lecture) for 10–25 minutes (at most, with a few exceptions), and then students would turn to the "active engagement" exercises (i.e.,

the lab material). When they finished looking at the material (we always asked if it was okay to move on, or we had them put bright sticky notes on their microscopes to indicate they were finished), we moved into the next content delivery section. This approach had numerous advantages:

a. Switching between listening and active engagement keeps students awake!
b. We could stop talking anytime so students could make hand sections and see for themselves what we had just been talking about. This immediate reinforcement with living material turned out to be a powerful teaching tool.
c. In previous years, we put all the plant material at the back of the room and had students pick up what they needed once lab began. Now, we put as much of the live material on their tables at the beginning of class as possible, so when they sat down, it was right in front of them. This had two advantages: (1) some students started looking at the material when they sat down, rather than their phones and (2) we could begin the unit with a question about the material in front of them; in other words, as much as possible we asked them to "Ask the Organism."
d. Students didn't finish units at the same rate. We encouraged anyone who was done to move around, go outside for a few minutes, etc. What happened most often was that students would help each other or just start chatting. At first, I was a little dismayed that they were talking about anything *but* what they were looking at, but I soon realized that if we didn't interfere, the conversation slid easily between a show they'd just watched to "Is this the secondary cell wall?" and then back to the show. We tried to keep the chatter at low volume and as far as I know, no other students complained that they couldn't concentrate. Encouraging the movement, breaks, and the social aspect helped boost the general enthusiasm and energy level during the long afternoons.

6. Lecture and lab exams were not separate. Instead, on the day of the exam, students would arrive to find a few plants (or slides) at their desk that they may or may not have seen before. If a living plant was represented, they would be responsible for making hand sections. The exam would consist of four or five questions that would require illustration, interpretation, and the rationale for their interpretation; most students stayed the full three hours to complete the midterms. From semester to semester, we tried letting students bring in references, i.e. their notes. They were not allowed to use the internet, though. As far as I can tell, allowing notes didn't really affect their grades much, but it did seem to reduce the stress associated with taking exams.

Another thing I've done since before we restructured the course is that I would grade the first exam, and then give everyone in the class the chance to redo it as a take-home, re-grade the take-home exam, and then record the average of their scores. I emphasized to them that my concern was for their learning, not their grades. In over 30 years of teaching, I had only one student complain to me that this approach wasn't "fair" to the good students. I pointed out that I don't grade on a curve, so the "mean" (and the comparison it implies) was not relevant. (I wanted students to know how they are doing as we went through the course, and not count on a mystical curve at the end to save them.) Students who scored well the first time didn't need to spend the extra time redoing the exam. I also pointed out that I generally only do this for the first exam. From my perspective, it helped the students who didn't do well on the first exam maintain some degree of interest in the course, without feeling like there was no "hope" of eventually getting a good grade. This perspective is completely selfish on my part, because who wants to spend the semester trying to teach students who don't want to be there because they have no hope of attaining their goals?

Student reaction to the integrated lecture/lab format was strongly positive, so the following year, I reorganized Developmental Plant Morphology to follow the same format. Since that time, a few other colleagues in my department have restructured their lecture/lab classes in a similar format as well.

Does it take more time? Probably. I arranged the rest of my schedule so that as much as possible, I devoted two full days a week to teaching, but very little time the rest of the week. And since I was in the classroom during the lab, I no longer needed to spend a few hours each week on TA meetings. The TA and I set up the lab together and I explained what I wanted students to see during that process. In order for the TA to gain more experience being in control of the classroom, I offered the TA the opportunity to be the lead instructor, i.e., providing the content and leading the engagement periods, on as many units as they wished. Most TAs were happy to lead one or two days out of the semester but didn't really want to take the lead more than that. Was the extra time worth it? For me personally, absolutely! This format seemed to make it easier to spark a deeper interest in the material. I felt like I got to know my students better, which helped me better understand their questions and responses to the material, and I ended up with additional insight into what aspects of the course worked well.

2. **Students like drawing**

The traditional approach to recording information in visually oriented courses (comparative anatomy, morphology, etc.) is drawing, but at some point, I began to worry that students would prefer to work in a digital format, i.e., that my approach was old fashioned and didn't involve the "latest technology." More and more students were using their phone to take pictures through the ocular of the microscope. While I've seen some amazing photos taken this way, getting the focus right requires very steady hands and careful positioning. To try to make this easier, in 2015, I received a teaching grant from my university to purchase a large screen (since technology in the old building I taught in was rudimentary) and ten iPad minis (i.e., one for each pair of students). I worked with the UConn's Technical Services department to design adapters that would position the iPad minis in place over one ocular for accurate focus. Now, for the first time, individual students could share though Airplay what they were seeing on their scope to the large monitor so that everyone could see it.

I also posted PDFs of each lab write-up so students could populate the lab write-up with digital photos that could be labeled in OneNote.

Surprisingly, almost all students preferred to draw on the lab handouts. For one thing, the iPad adapter ended up being slightly cumbersome to set up and remove, and since it blocked one ocular, students preferred not to keep it mounted on the scope. More importantly, students also told me that especially since the pandemic and flipped classrooms, almost all of their education was digital. They spent hours upon hours each day in front of screens, so it was actually a relief to come look at something and try to draw it.

3. **Students want to do well, but life gets in the way**

The first decade of my career I was always on the watch for people cheating, wary of those trying to take advantage of the system, and of me. I was skeptical of excuses. I became much more sympathetic, and I think a better teacher, when my step-kids became university students. I finally began to understand the student experience from the student perspective. If students missed assignments or didn't perform well on a test, I could appreciate that they had other things going on in their lives besides my course. Almost all were pursuing minors, double majors, and multiple club or organizational activities, in large part responding to stress of building their resumes. After I switched to the integrated lecture/lab structure, I also learned just how many of my students went from my class directly to a job.

Many people have suggested that course evaluations from students don't reflect student learning. Perhaps… but evaluations often reflect how students feel about a course.

Students might not remember the details of what we tried to teach, but they will remember how they felt about a class and by extension, the subject matter. More than anything else, my goal as an educator was to leave students with an appreciation (dare I say love?) for plants and how they grow, to teach through awe and discovery as much as possible, and to respect them as people.

Are there things I wish I'd done differently? Absolutely. In hindsight, I wish I had incorporated more inquiry-based techniques than I did. Even so, nearly all students reported on evaluations that they learned more, or much more, than in their other classes. One thing that worked well was to conduct scavenger hunts inside our UConn Botanical Conservatory (aka, The EEB Greenhouses). Scavenger hunts proved to be effective teaching tools because students had to use their skills to rule out possible candidates, as much as to investigate those that exhibited a feature of interest. I recognize that an incredible collection of plants in greenhouses adjacent to our teaching lab building has been an incredible privilege. It also has been one of the greatest joys of my career.

4. **Spend more time outside**

Despite our amazing indoor plant collection, I regret that I didn't have students spend more time outside in both plant structural diversity and developmental plant morphology. Over the last two decades, many studies have shown that outdoor classrooms and educational activities are incredibly effective for increasing concentration, creativity, and retention in children (e.g., Coyle, 2010; Kuo et al., 2017). The benefits of outdoor classrooms at the college level are understudied (Birdwell, 2024), but based on feedback from students, the few units of my courses that did require spending time outside (e.g., tree architecture) were always the most popular. Some of the scavenger hunts in the greenhouse could be converted to outdoor activities, weather permitting, if I had made the effort. I wish I had.

I have come to believe it is possible to teach our traditional courses like plant anatomy in such a way that students not only come to appreciate plants, but also develop an understanding, even if subconscious, of a plant's place in the world, while at the same time deepening their own connections to the natural world. Would it take some effort to revise my courses again to do so? Absolutely. But at a time when over 80% of Americans live in urban environments, it feels imperative to give it a try. Hopefully, future generations of botanical educators have already, or will tumble to this realization sooner than I did.

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Universal Design for Learning Botany

By J. Phil Gibson

Professor, School of Biological Sciences
University of Oklahoma

My colleague Dr. Drew Hasley recently began a seminar presentation with what appeared to be a blank, white screen, and he asked the audience to read what it said. Although we were unable to read the text on the slide, the software on Drew's computer—something he uses daily to do all the things we think of as the "typical work" of a scientist—was able to detect and read the title of his talk. The title was written in a white font on a white background, and Drew, who is blind, explained that font color and background are irrelevant to screen readers. He then said, "People are not disabled. It's environments that are disabling." Following this incredibly powerful combination of demonstration and statement, he proceeded to describe what can and must be done to improve accessibility to STEM education in our classrooms, lecture halls, and laboratories.

The question, the challenge, the hurdle that undoubtedly arises for many of us when we consider accessibility for our science classes is: "How can I adjust my teaching spaces and practices to be more inviting and provide opportunities for all students to learn?" There is no one-size-fits-all answer to that question. Some solutions may be relatively simple, such as giving extended time on assignments. Others may be more challenging to discern and implement, such as making a laboratory activity compliant with the Americans with Disabilities Act. Regardless of the complexity of the problem, Universal Design for Learning (UDL) can be an effective starting point to help teachers identify strategies and solutions to support learning for all students and help them achieve their goals as a scientist regardless of a student's visible or hidden disabilities.

UDL is based on the architectural principle of Universal Design, in which constructed environments intentionally contain design features to improve accessibility or use for one group of people that absolutely needs that specific design element and can also provide emergent benefits to others. The classic example is a feature we regularly see on sidewalks called "curb cuts." These small ramps are commonly found in curbs and at intersections. They are essential, and required by law, to help individuals with mobility issues use wheelchairs or walkers to safely navigate sidewalks. However, they also benefit people pulling luggage, pushing a cart, or many other activities where the curb is anything ranging from a nuisance to a literal barrier. Automatic doors provide a similar benefit. Some people need them, while others benefit from their availability. UDL is based on the same idea. By designing and providing educational experiences that intentionally include features essential for some students to use them, we can also provide both anticipated and unanticipated learning benefits to everyone in the classroom.

UDL originated with the educational non-profit group CAST. Their mission for over 40 years has been to promote learning spaces and experiences that "are intentionally designed to elevate strengths and eliminate barriers so everyone has the opportunity to grow and thrive" (CAST.org). Their approach prompts educators to recognize that there is no "typical" student and that the real "normal" situation in any classroom is a range of differences among our students in how they learn and express what they have learned. UDL breaks these differences into three categories: Engagement, Representation, and Action/Expression. CAST researchers have shown that these areas are fundamental to how learners interact with lessons, perceive and take in information, and demonstrate their understanding, respectively. For each of these categories, there are three elements: Accessing (how students can obtain and use information and resources), Building (how students construct knowledge, skills, and understanding), and Internalizing (how students reflect upon, apply, and retain learning). CAST combines the three categories and their three elements into the UDL guideline matrix (https://udlguidelines.cast.org) to give educators suggestions for modifying lessons and removing unnecessary barriers to make learning opportunities available and meaningful to all students.

For example, suppose you invite a speaker to your class, but you have a student who is hearing-impaired. The challenge in this situation lies at the intersection of Representation and Access in the UDL guidelines matrix. A suggested solution is to provide an alternative means of representing what the speaker is saying, such as providing a real-time transcript or an American Sign Language (ASL) interpreter. While these items are essential for our hypothetical student, the transcript could also benefit students seated in the back or in a noisy part of the room, or perhaps someone who missed the lecture. The interpreter could potentially even benefit students studying or who know ASL. Likewise, the experience could increase awareness and stimulate interest to learn ASL. Providing collections of slides before class is another example. Some students may have an accommodation that requires providing lecture slides to them beforehand, but providing them to all students can benefit others as well. The reasons of how or why they could benefit other students is irrelevant. Unless there is a specific reason that sharing them would somehow hinder learning, why not give everyone the benefit of having the resource?

Other challenges require more complex solutions. For example, my classes frequently involve constructing and interpreting phylogenies. For a blind or low-vision student, learning these things is an immense challenge. Through my collaboration with Drew Hasley, Kristin Jenkins, and Hayley Orndorf, we modified an existing tree-thinking resource called the Great Clade Race (1) that uses symbols printed on cards and is therefore dependent on vision to teach tree thinking by converting it into one that uses tokens, making it a Tactile Clade Race (2). The tokens are accessible both visually and tactilely, so just like a previous example, different forms of representing the information increased accessibility by removing the barrier of vision-only access. All other elements of the activity remained the same, and assessments demonstrated its effectiveness at teaching the concepts and skills (2). However, we also noticed that in the tactile version, students worked as teams and completed the activity faster than for the visual form. This revealed several unintended and unanticipated benefits of our modification. And therein lies the true value of UDL: it stimulates changes that are essential for some but beneficial to all.

UDL is neither a step-by-step process nor a curriculum structure one can follow to make lessons and resources accessible. Rather, UDL is a set of guidelines and suggestions for considering and identifying items to change. It should be thought of as an approach or perspective rather than a checklist to solve problems. Through thoughtful consideration of course goals and learning objectives, UDL can help frame issues and identify solutions. For example, essay questions are common components of exams and other assessments to evaluate learning. However, consider whether an essay is the only way a student can express understanding. When grading an essay, ask yourself if you are also using their writing and grammar skills as indicators of understanding the topic in the question. Those are two different skill sets. If writing is part of the assignment, learning goals, and rubric, there is nothing wrong with evaluating writing itself—but what if your goal is to determine if the student understands a botanical concept such as the structure of a flower? Would a diagram be an acceptable way to demonstrate learning as well? What if they are not a particularly strong wordsmith, but they are excellent at producing diagrams? We have all told students at one time or another that we are not grading their artistic skills when we ask them to produce labeled diagrams in assessments. But how often do we extend that same leeway to questions when, for no specific pedagogical reason, we ask for or expect written answers by default or because that's an easier question to write? Providing multiple, appropriate means of expression to show understanding is a solution at the core of UDL. If you are hesitant about that suggestion, consider this. In a recent workshop, a UDL expert demonstrated how a UDL perspective can help us better promote and evaluate learning. Here is a botanical modification of their activity to demonstrate this point. Get a pen and paper and draw a flower. First use your dominant hand. Do the same using your non-dominant hand. Now hold the pen or pencil in the crook of your arm or with your foot to draw a flower. Now suppose I am evaluating your knowledge of botany based on whether you drew the parts correctly and how well you drew a flower with your foot. Although some of you may draw quite well with your foot, that would hardly be a fair assessment of knowledge, right? I may have a perfectly valid reason for trying to find someone who can best draw a flower with their foot. But if what I want to determine is whether you know the parts of a flower and how they are put together, why would I try to base my evaluation of knowledge on the quality of the drawing? We make a similar mistake when we expect students to demonstrate thoughts and knowledge in a restricted way that may not allow them to be at their best to express them. When we use writing skills to evaluate knowledge of something else, we are making the same error as in my flower-drawing example. UDL provides ways to prevent that from happening. I am not advocating that we let students decide which assignments they will do or the form they will take for all assignments, although that is an intriguing idea. What I am asking you to consider is whether there are other ways, or more available options, that would allow students to do their best work.

There might be one question remaining that you are asking about UDL: "Why do this before I need to do it?" Of course, we would all provide any accommodations for students upon being informed by the appropriate campus office, and so one could wait until the need arises to do any of this. To that point, I ask that you consider the differences between accommodation and accessibility, and the consequences of their differences on teaching and student experiences. Both share the important goal of increasing inclusion of all learners in the classroom or laboratory. However, accommodation typically involves reacting to specific needs once made aware of them—usually just before the start of a semester only a few days away—and then modifying lessons, activities, or assessments so they can be used by a particular learner. This often results in frantic, last-minute changes at a time when there is little free time available. In contrast, thinking about how one can improve accessibility via UDL takes a proactive approach by carefully considering, designing, or modifying lessons and activities from their inception or as part of regular curricular updates to include features that are essential to support learners that have specific needs and can potentially benefit everyone.

This approach to solving problems beforehand usually results in more thoughtful solutions that are aligned with learning goals rather than last-minute modifications that just need to be "good enough" to work. A proactive accessibility stance is better than a reactive accommodation stance for several reasons. It increases inclusivity by ensuring that learning environments and experiences allow everyone, regardless of ability, to participate fully. It is more efficient simply because including accessibility features upfront saves the instructor time as compared to adjusting later. Anticipating learning challenges and student needs is also empowering for individual students because it gives them the freedom to navigate their learning and opportunities to do so without asking for special accommodations. Last, and possibly most importantly, using a UDL stance to increase accessibility benefits for everyone in the classroom or lab creates a positive learning and working environment because it promotes a culture of inclusion and respect for all students and their needs.

Albert Einstein once said, "Everyone is a genius. But if we judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid." We should think about that before we step into our classrooms. We often teach and assess in ways that are comfortable to us, ways we have experienced, ways we would show our understanding, or ways that we haven't really dissected pedagogically. It's easy to think that if it worked for us, it must be good—or at least it will work for the average student. As I mentioned earlier, the average student is a mythical creature. Our students are a rich tapestry of diverse needs, experiences, goals, abilities, and motivations. We must remember that what we do in the classroom or laboratory is about providing students experiences and opportunities to learn, gain skills, develop skills, and do their best. I am not asking anyone to immediately make wholesale changes in their teaching. I am asking that we all at least examine our classes through a UDL lens, and identify one thing or one aspect of a course or a lesson that can be improved by UDL modifications. Doing that one little thing can have a huge, positive impact. As botanists, we are quite familiar with that idea. Just remember that doing one little thing to increase accessibility is just like planting a seed. And we all know how the one small action of planting a seed, like knowledge, can have huge consequences once it starts to grow.

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Field-Based Courses Still Matter, but not Like They Used To

By Christopher T. Martine

Department of Biology, Bucknell University

A few days ago, I had a visit with my Field Botany class to the campus farm on the southeastern edge of Bucknell University, where I have been employed as a professor since 2012. The visit to the farm, where we met crop plants and discussed their taxonomic connections to the wild species we have thus far learned, capped off a big week for our group. For the previous class we left campus at 7:30 a.m. for a 4-hour trip to the Mohn Mill Natural Area, a designated Wild Plant Sanctuary in Bald Eagle State Forest. The site, just off Pennsylvania's Mid State Trail, is dotted with large circular vernal pools populated with enough "Osmunda" ferns to make one feel as though you have stepped back into the Jurassic. But the highlight of this annual excursion is always the moment when I tell the students, as they are lined up across a narrow wooden bridge on the Mid State looking down into the forest, that—only 5 weeks into the course—they would be hard-pressed to find a tree, shrub, forb, or fern that they don't recognize and know the Latin name for (Figure 1).

This group of 17 juniors and seniors had learned something like 75 species by that point, so their handle on this particular woodland was a function of similar plant communities we've visited and the plants we've seen in them (and, of course, the work the students have put in to memorize Latin names and recognize species when they come into view). Still, even with caveats, staring into nature and realizing you are seeing it in an entirely different way than a month ago is a powerful and deservedly pride-inducing moment.

So who are these students? Almost all of them, like many of the students I have taught in 19 years of professing at Bucknell and SUNY Plattsburgh, are Biology majors taking my class to fulfill an upper-level requirement in ecology/evolution. Many of them are headed for careers in health and medicine; a number of them will be MDs. Content-wise, Field Botany is a one-off for the majority of my enrollees. And, if I am being honest, this is one of the best things about teaching the class: it is a one-semester opportunity to initiate a life-changing shift in perspective.

When I took my first field course, Dendrology, at Rutgers University in the fall of 1993, this is exactly the shift that happened for me. I added a few more undergrad course-based field experiences, thereafter, including two 5-week summer field courses in Newfoundland and in Alaska. But, for me, the die had been cast the moment I aced my first tree/shrub identification quiz. I knew that I would someday seek out opportunities to teach in similar ways, with the hope and intent to connect students to nature by teaching about real things in real places.

I started as an undergrad TA in that same Dendro course; later, as a Master's student, I taught the whole class as a sabbatical replacement. Working

Figure 1. *Students enrolled in the 2024 edition of Field Botany at Bucknell University on Pennsylvania's Mid State Trail, one of 20 locations the class will visit this semester.*

for two government agencies I managed K-12 outdoor education programs and then, privately, co-ran a few years of K-4 summer outdoor camps with my wife, Rachel. And when I got my first tenure-track job at SUNY Plattsburgh in 2006, I immediately added Field Botany to the Biology curriculum. At that point in time, the students I was teaching had had childhoods a lot like mine. Students who were 21 or 22 years old in 2006 were born in the mid-1980s; they had dealt with idle time free of constant smart phone access. They were inherently aware of their surroundings much of the time.

Yet by the time I arrived at Bucknell in 2012 and developed a new version of Field Botany, I could already tell things were changing. So could a lot of people, as perhaps best evidenced by the publication and popularity of Richard Louv's Last Child in the Woods in 2013—and the suddenly widespread use of the phrase "nature deficit disorder."

Some would say things have only gone downhill since then. Students who are 21 or 22 years old in 2024 were born around 2003. Everything about their childhoods was different from mine. Smart phones, tablets, laptops, constant connection… and constant reasons for not being outside, or taking long hikes, or camping or fishing or looking up at the night sky. These students grew up over-scheduled, over-managed, and overly focused on extracurriculars and youth sports. Many spent years of their lives outside—but on athletic fields, not in the woods or down in the creek. Their connection to nature has been mediated by screens or experienced through enough filters to make nature itself feel like artifice. The distance between students and a comfortably broad understanding of the biodiversity around them persists even after heading off to university.

Upon arrival to college, Biology and similar majors are often now plugged into courses with integrative approaches that have become the way we introduce biology at many institutions, with current students not experiencing (for better or worse) the same semi-exhaustive march through general biology content that previous generations faced. Case in point: Bucknell's new four-course introductory core sequence. Lauded on campus for an approach focused on student retention, skills-building, and accessibility, our content-based courses consist of case studies that vertically integrate subdisciplinary content. What was once a 4-week unit on plant diversity and evolution is now a 4-week module on "Milkweeds and Monarchs" touching on topics including ecological niches, interspecific competition, plant response to herbivory, transport across membranes, neuron structure and function, impact of mutations, and predator adaptation. It's all pretty great and students gain a lot with this approach, learning to understand the multi-dimensionality of biological problems. But one trade-off is that they also receive less traditional content, including a deep primer on general botanical concepts. When these students arrive as juniors or seniors in my Field Botany class, they typically know little about the life of plants unless they have learned it outside of their formal education.

"Get off my lawn/front-yard-wildflower-meadow," cries the old-guy botanist.

I am (in this moment) not being that guy, however. Because as much as the above items do present a challenge, they also present an important opportunity.

For proof, let's return to the Mohn Mill Natural Area, where my class spent time hanging around a sphagnum-dominated mountain "boglet" discussing glacial cycles and rates of decomposition. A student later reflected that they had heard about bogs in other classes, and even learned the story of "Tollund Man" (the ancient preserved body recovered from a bog in Denmark), but they never imagined that they might live anywhere near a similar sort of place—let alone one they would someday visit IRL. To be standing in an actual "bog," feeling the give of the peat, allowing the water to infiltrate your old pair of sneakers and soak into your socks… to be introduced to plants that grow nowhere else but in these particular habitats and to understand why… this completes the picture. This is the stuff you now never forget.

When we teach field courses, we provide the context to so much of what our students have already learned and may learn later on; it is integrative biology on steroids.

Increasingly, these courses are also providing the first real opportunities for students to experience nature in meaningful ways. As a baseline, even before the content delivery and the graded assessments, this is already enough to change the way a person feels in the world and to spark an appreciation for the life around them. This is why field-based courses still matter, but not like they used to. These days, they might just matter more than they ever have.

Neo-Natural History: Careful Observation and Co-Discovery in Teaching Botany

By Joan Edwards

Williams College

A key feature in connecting students to nature and the botanical world is to get them to "see" the diversity of botanical textures in the green world around them. Neo-natural history, where we take a closer look at each plant, adds new dimensions and wonder at the way we look at plants. It trains the eye to recognize the importance of plant diversity in scientific discovery and to understand the critical role of plant diversity on our quality of life. If we are to make progress in addressing the two main environmental crises of climate change and biodiversity loss (Figure 1; Pörtner et al., 2023), an appreciation and understanding of the multiple ways plants provide solutions is critical. Plants are key in solving these dual environmental crises (Griscom et al., 2017; Pörtner et al., 2023; Zielinski et al., 2023). There is no more important time than now for us to teach plant diversity both to make new discoveries and to find creative solutions to environmental problems.

Seeing the diversity of plants first hand in the field and lab provides an indelible experience that trains the eye to see, leads to new discoveries, provides examples of the power of the comparative approach, and gets students to recognize the critical role of biodiversity in our environment. With over 400,000 plant species globally (Enquist et al., 2019), we as botanists are blessed with having an almost limitless number of species to explore and to fuel new discoveries. Almost every plant has something unique or special. From the seemingly simple morphology of bryophytes to the extraordinary diversity of the most complex flowers, fascination dominates. Here I highlight

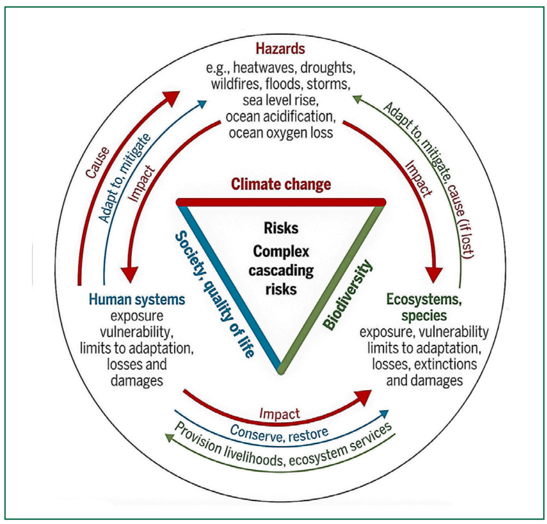

Figure 1. *Plant diversity can provide solutions to the twin environmental crises of climate change and biodiversity loss, which are coupled through human-caused dynamic interactions. Each of the three factors on the triangle (biodiversity, climate change, and society) impact each other (red arrows). Humans have the ability to improve our quality of life by mitigating the negative impacts (blue arrows) and in return, restoring, or gaining valuable services (green arrows). (Adapted from Pörtner et al., 2023.)*

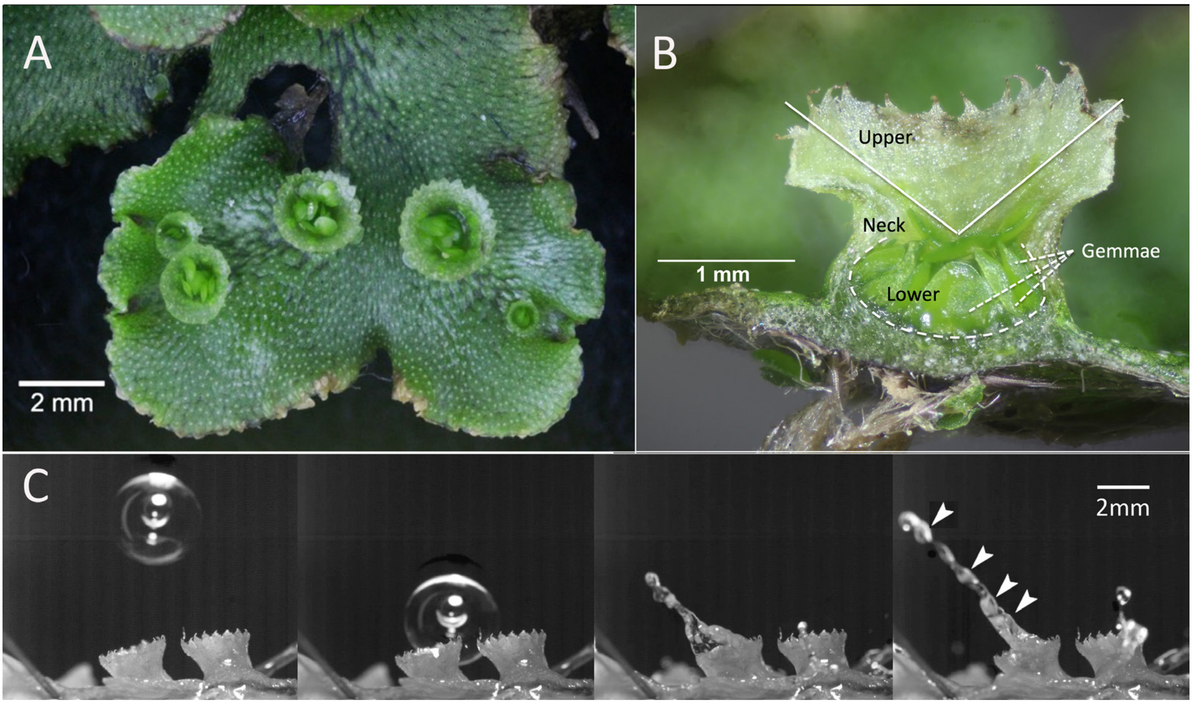

Figure 2. *(A) Top view of the dichotomously branching liverwort,* Marchantia, *with mature and developing gemmae cups extending from the surface. Individual cells, each with a central pore (white dots) are clearly visible. (B) Longitudinal section of a gemmae cup shows a lower chamber that produces gemmae and a funnel-shaped upper chamber that captures the energy of a falling raindrop and jettisons the gemmae. (C) Still frames from a video of a water drop hitting a gemmae cup and transporting gemmae-filled droplets (arrows). Filmed at 3000* fps *with a 20-*ms *exposure. Parts B and C are from Edwards et al. (2019).*

two approaches. The first is to look in depth at multiple features of a plant to highlight how they persist and their role in the environment. The second is to look at a plant over time to chart the evolution of plant behavior. I describe easy-to-access examples that may surprise, delight, and inform.

Looking closely at the multiple dimensions of a single plant creates a fuller picture of plant function and its role in the environment. An excellent example is close examination of *Marchantia* (Figure 2A), a relatively easy to access liverwort often growing at the base of buildings (even in February), but also found as a "volunteer" in greenhouses.

These small non-vascular plants are worth a close look because they are relatives of the first land plants (Qiu et al., 1999) and had a profound impact on the environment. These early cryptospores were responsible for lowering the atmospheric levels of CO_2 and for triggering a mini–ice age during the Ordovician over 400 mya (Lenton et al., 2012). They are also responsible for the current levels of oxygen in our atmosphere (Lenton et al., 2016). There is almost a disconnect when students realize these small, seemingly inconspicuous plants had such a profound impact on our environment. If small liverworts can impact climate, what about the impact of eight billion people?

If we look at *Marchantia's* relatively simple morphology (Figure 1A), we see a dichotomously branching ground creeper that can never grow tall but can hopscotch across the landscape by harnessing the power of raindrops to jettison gemmae to new locations. The gemmae cups (Figure 2B) provide an example of evolutionary design where the urn shape provides a lower chamber in which new gemmae are produced and the top funnel shape serves as a launching site to

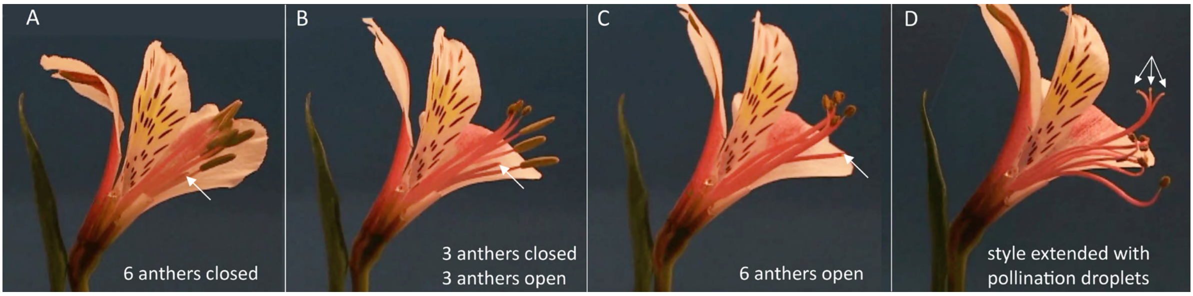

Figure 3. Alstroemeria *flowers are protandrous, starting as male and switching to female. (A) All six anthers are still closed and the style is immature. (B, C) Male phase. Anthers mature in two groups. First, three anthers curl up and dehisce (B) and then later the remaining three anthers curl upwards and dehisce (C). (D) Female phase. The anthers have dropped down and the style has extended, curled upwards and split into three stigma lobes each with a pollination droplet. Stills are from a time-lapse video filmed in the lab over nine days. The tip of the style is indicated by arrows.*

capture the energy of a falling raindrop to splash and propel mature gemmae, which have risen to the surface. *Marchantia* thus provides a lesson in biomechanics and dispersal mechanisms for a non-vascular plant.

If we follow a plant over time, we can document movements in plant behavior and gain insight in terms of floral design, breeding systems, and maintenance of species in nature. Plants are unexpectedly agile in their movements that range from the explosive flowering in the bunchberry dogwood (*Cornus canadensis*), which opens in <0.5 ms (Edwards et al., 2005), to the more subtle movements of phototropisms and geotropisms. Here I highlight three examples of flowers that use movement to switch from one sex to another.

The first example is *Alstroemeria*, a genus native to South America, but almost always available in florist section of local grocery stores. *Alstroemeria* flowers are protandrous, where anthers dehisce first; later, the style lengthens, curves upwards, and splits into three lobes, each topped with a pollination droplet (Figure 3). Using florists' samples, students can observe these changes directly in real time.

The second example is the flower of spring beauty (*Claytonia caroliniana*), which is accessible in New England for field observation in the early spring. The flowers of *Claytonia* are also protandrous. In a field population, flowers are typically in different stages of development. On the first day of flowering, stamens are held erect and dehisce presenting magenta-colored pollen. On the second day, stamens reflex back and the style splits into three stigma lobes (Figure 4).

Figure 4. Claytonia caroliniana *flowers are protandrous. On day one of flowering, the stamens are held upright and dehisce, presenting pollen. On day two, the stamens bend back toward the petals and the stigma splits into three lobes. By day three, most flowers begin to close.*

The final example is the flower of the iconic skunk cabbage (*Arisaema triphyllum*), which, if available, is well worth a field trip to observe the plants in situ. This allows one to experience first-hand the strong skunky odor, the wet swampy habitat, the extraordinary structure of the spathe and spadix, and the behavior of the flowers. Here in New England, skunk cabbage is our earliest blooming wildflower. It has protogynous flowers (Figure 5) but is also amazing in heating up to 35°C above ambient air temperatures with a metabolism equivalent to that of a small mammal (Knutson, 1974), producing a skunk-like odor, and having specialized idioblast cells filled with double pointed raphide crystals. When broken, idioblasts shoot out these glass "spears" presumably as a protection against herbivory (see video in Pickett-Heaps and Pickett-Heaps, 1984).

Looking closely at plants both in the laboratory and in their natural setting can be foundational, can serve as a key part of teaching botany, and can contribute richly to learning and discovery in botany. Most students long remember visiting skunk cabbage in its native habitat, or a visit to a Sphagnum-dominated kettle-hole bog, or even observing the self-digesting flowers of *Tradescantia*, the unfolding and sexual switch of an *Alstroemeria* flower, or the sparkle on a *Pelargonium* petal. The list is endless. By providing a full context for plant behavior and enriching it with direct observation in both the field and the lab, we can give students an entree into new discoveries, train their eyes to "see," and provide them the tools to interpret plants and their role no matter where they go. If we are to solve our twin environmental crises of biodiversity loss and climate change, a keen eye and a knowledge of the diversity of plants is key.

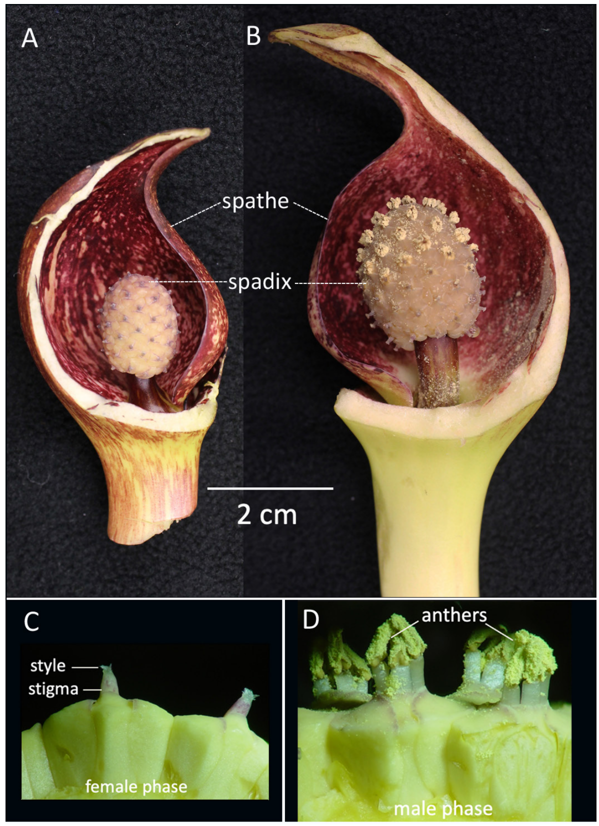

Figure 5. Symplocarpus foetidus *flowers are protandrous. (A) Spadix with flowers all in female phase. (B) Spadix with flowers transitioning with the upper flowers in male phase and the lower flowers still in female phase. (C) Female phase flowers showing the stigmas and styles just protruding from the petals. (D) Male phase flowers with stamens, which have extended above the petals and dehisced presenting pollen.*

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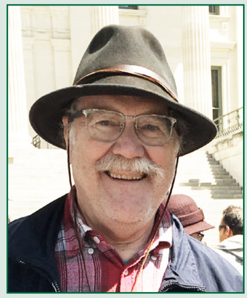
Using Inquiry as a Tool to Help Students Develop a More Sophisticated Understanding of Frequently Misunderstood Concepts



By Marshall D. Sundberg

Roe R. Cross Distinguished Professor of Biology – Emeritus, Emporia State University, Emporia, KS

As a college sophomore in 1968, I was first introduced to a novel way of instruction by my botany professor, William Muir. Muir's approach was unique in many ways, starting with the fact that he had just lost his sight as a complication of diabetes. He lectured, without notes, and drew sketches on the board using one hand as a placeholder as he sketched—and then quizzed us to be sure we understood what was being illustrated. If you were the one called on, you would have to carefully describe what you saw and what it meant—carefully enough that someone who could not see it (Dr. Muir) would understand what you meant. For the rest of my career, this was a tool I would use, particularly in lectures, whether it be for small seminars or lectures of more than 300 students. Several examples are described below, and many are also included in Uno et al. (2013). (Copies of this book are still available from the BSA office: https://crm.botany.org/civicrm/contribute/transact?reset=1&id=8.)

A second unique approach was to critique the textbook, as necessary, during the course of the class. This was only done occasionally, and for "big" things in the introductory course, but it was a main component of upper division courses. For the latter, this consisted of mimeographed handouts of corrections, elaborations, or current research, related to the chapter being discussed. I still have many of these as folded chapter inserts in undergraduate textbooks I've kept in my library. I'll give some examples below of the kind of textbook "updating" I used in class. The "mimeo handouts" remain the model I use when reviewing manuscripts and textbooks.

The third characteristic that set Muir apart was his philosophy of science. Virtually every science teacher I ever had, including Muir, emphasized the power of science in developing an understanding of nature. But Muir also emphasized the limits of science. The usual way of doing science emphasizes finding a solution to a particular problem, but this narrow focus often results in unintended consequences that might have been avoided if a broader perspective was used. Especially in applied science, implementation is often dependent on many different non-science constraints: economic, legal, environmental, social, religious, and more. Finally, the fact that science grows by building on the foundation of existing knowledge (accretion) makes it very difficult to accept any paradigm-shifting innovation. I begin with my favorite example of a paradigm shift that occurred during my career.

Accepting a Paradigm Shift

Endosymbiotic Origin of Eukaryotic Cells

In the 1960s, it was just becoming accepted that bacteria and blue-green algae were closely related and shared features termed *Prokaryotic*.

One taxonomic question was "Should at least the bacteria be split out of the Plant Kingdom?" The author of my textbook (Cronquist, 1961) put them together in a single division separate from the rest of plants. Regardless, everyone agreed that blue-greens evolved from bacteria and the green algae probably did as well. Both were the result of repeated mutations, recombinations, and natural selection over the course of millions of years. At the start of my Plant Evolution course, Spring Term 1970, Muir made us aware that a young biologist, Lynn Sagan [Margulis] had published a paper 3 years earlier suggesting eukaryotic cells arose via symbiosis between pre-existing prokaryotic cells. Two years later, as a rookie grad student, I listened to her plenary address at the 1972 American Institute of Biological Sciences Annual Meeting in Minneapolis. It was in Northrup Auditorium with several thousand biologists present. At the end of her talk, half the audience was politely applauding, but the rest were jeering! This was my introduction to professional scientific meetings and thankfully, I've never seen anything like it again. Evolution by anything other than natural selection was considered heretical. Endosymbiosis is one of those paradigm shifts that is now well accepted, and I've told this story every time I've taught it. I approach this in class by presenting the traditional interpretation, the new alternative, then asking for what kind of evidence would be necessary to support the alternative. Now, here's the evidence and we can move forward.

Primary Root Growth

This is an example where the lecture component is covered in "Inquiring about Plants" (pp. 80-85). Briefly, I present students with a macrophotograph of a growing root tip and ask individuals to describe different parts of the image and/or speculate on the possible function of a particular part. We finally focus on the "naked" tip and switch to a photomicrograph of a longitudinal section showing the root/root cap junction (Figure 1).

I tell students to make a sketch of the general patterns they observe and to predict how cell divisions might produce these patterns. Finally, based on their interpretation, where would they expect most cell divisions to occur? The patterns suggest this should be near the arrow in the figure and this, in fact, is what was in Cronquist's (1961) textbook. I then show the radiomicrograph and explain how it was made (Figure 2). Onion roots were grown for 24 hours in a tritiated thymidine solution so that any nucleus that underwent mitosis would pick up the radioactive tracer. The dark spots cover nuclei that picked up the tracer. The region we thought would have the highest mitotic activity actually has the least: the quiescent center. This was first proposed by Clowes (1950), but it was 6 years before he confirmed his theory using radioactive tracers as shown above. I then challenge the students to devise an experiment we could actually do in our laboratory, in a single lab period, to confirm the presence of a quiescent center. The hint is mitosis and we'll see this below.

Some other paradigm shifts during my teaching career include transposable elements modifying the Central Dogma of DNA and the role of epigenetics in producing "inheritance of acquired characteristics": a neo-Lamarckian, and even neo-Darwinian "gemmules" concept. A possible paradigm shift, in process during the last decade, relates to consciousness and behavior in plants. Schlanger (2024) provides a readable, well-documented lay account of the current status of this theory.

Challenging the Textbook

Primary Growth of Roots

Clowes (1950) first discovered the quiescent center by looking at the distribution of mitotic figures in longitudinal sections of root tips. This is where I lead students in my question above. However, what I'm interested in during this lab is not just finding evidence of the quiescent center, but in examining the relationship between cell division and cell enlargement in the growth of the root. For the latter, any old onion root tip slide will do, but if you also want to identify the quiescent center you must use a near-median section. When I first developed this activity, I examined every onion root tip slide in the department's collection for all courses. Out of more than 200 slides, only 22 were near median and I set these

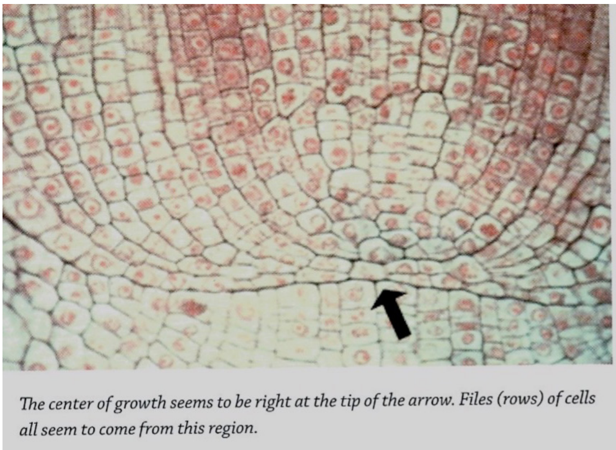


Figure 1. *Longitudinal section of a maize root at intersection between the root cap (below) and tip of the root apical meristem.*

Figure 2. *Radiomicrograph of an onion root tip in median longitudinal section. Black covers nuclei that emitted radiation by incorporating labelled thymidine into their DNA following cell division.*

aside specifically for this lab. The procedure for this lab is detailed in Sundberg (1981). Students observe four sequential fields of view, at 40X, beginning with the intersection between the root cap and root apical meristem at the bottom edge of the first field. They must determine the average cell length and width from median vertical and horizontal files across the field. Estimate the total number of cells in the field by dividing the area of the field by the area of a single cell and calculate the mitotic index (MI) (number of cells showing mitotic figures / total number of cells) X 100. (An additional benefit of this lab is the necessity to do some basic mathematical computations.) To indicate the presence of the quiescent center, divide the total number of cells in the field by 3 and separately calculate MI for the estimated bottom, middle, and top thirds of the first field of view, centered just above the root cap (fields IA, IB, and IC). When data collection is completed for this field, move the slide so cells at the top edge of the original field are now at the bottom of the new field of view and observe and collect data for the entire field II. This process is repeated for fields III and IV. Plot the data as in Figure 3. In general, as you move from the tip to the base of the root, the average cell length increases and the MI decreases. The low MI in field IA is an indication of the quiescent center. These is the types of data originally used by Clowes to predict its presence.

Finally, I ask students to make a sketch of the entire longitudinal root they observed and then, based on their data, label the zones of cell division, cell elongation, and cell maturation as is often found in textbooks. Figure 4A is from Campbell (Urry et al., 2023) and 4B is from Raven and Johnson (Raven et al., 2023). Do you see the difference in the labelling of these zones? Which figure is supported by the student data in Figure 3? (Hint: Are the zones discrete or do they overlap?)

Monocot Stem Structure

One of my favorite examples of challenging the textbook in lecture involves the structure of monocot stems, and I feature it in “Inquiring about Plants.” Most biology textbooks describe

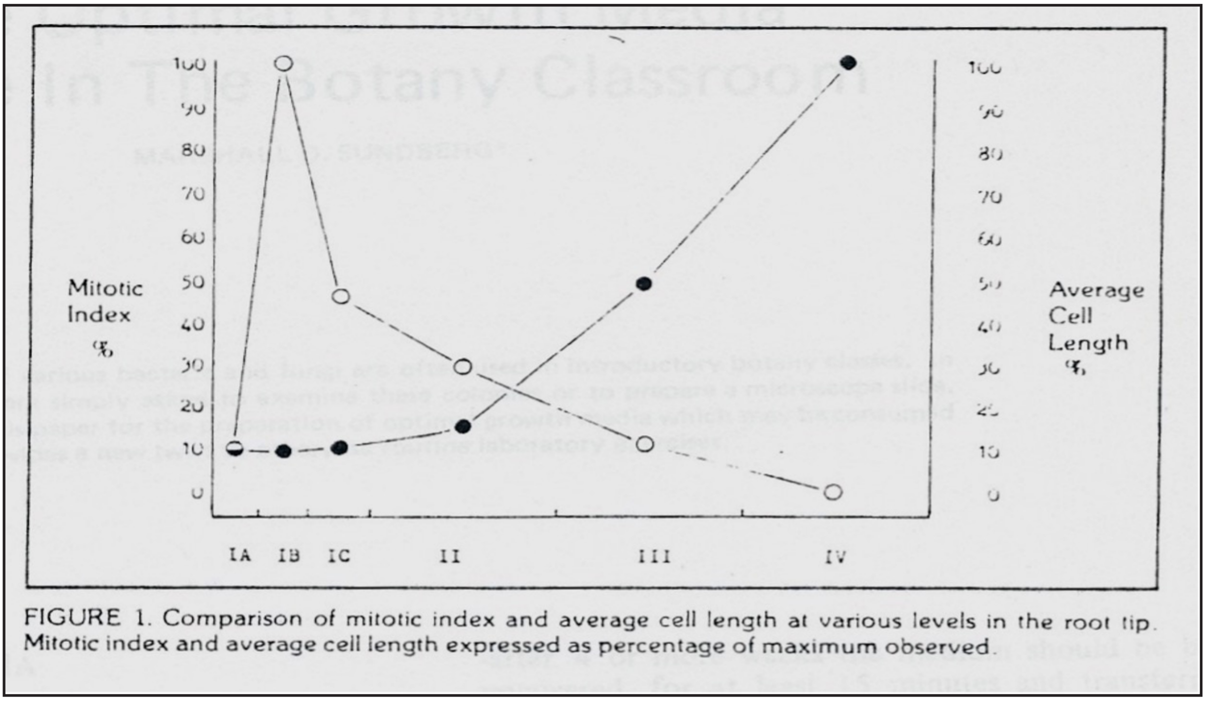


Figure 3. *Comparison of Mitotic Index (open circles) and Average Cell Length (closed circles) along root tip axis from junction with root cap (IA) towards root hair region (IV).*

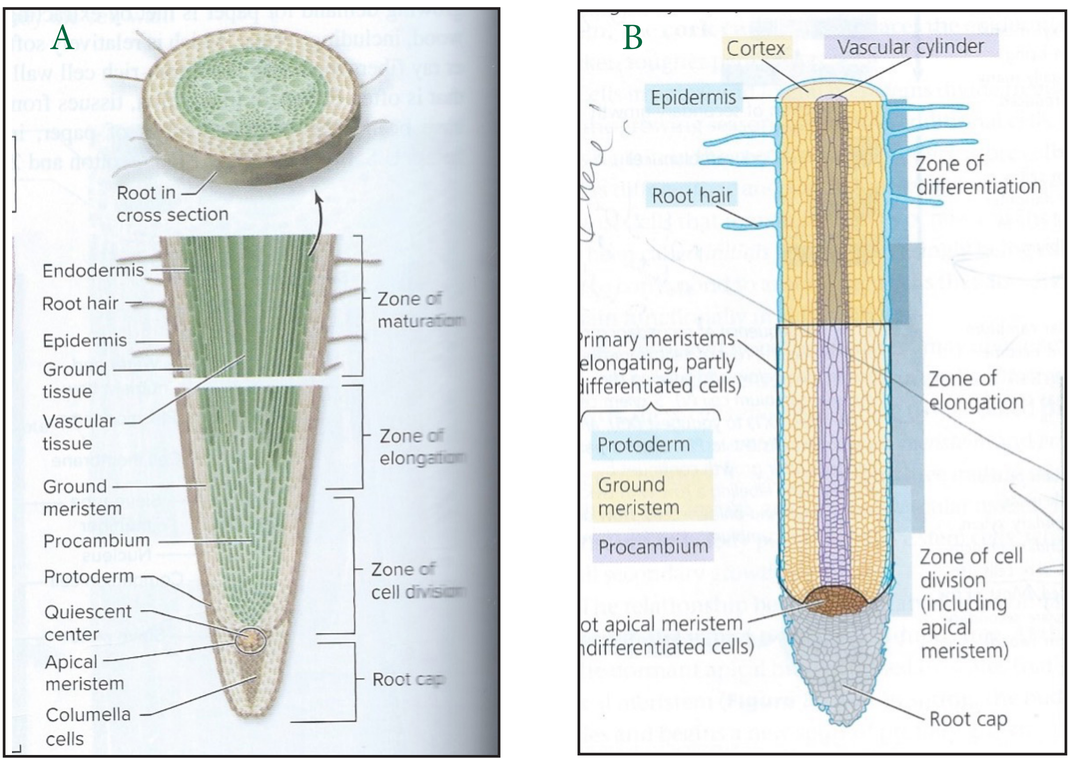


Figure 4. *Comparison figures of Zones of Cell Division, Elongation, and Differentiation in two popular contemporary textbooks. (A) Urey et al., 2023. (B) Mason et al., 2023.*

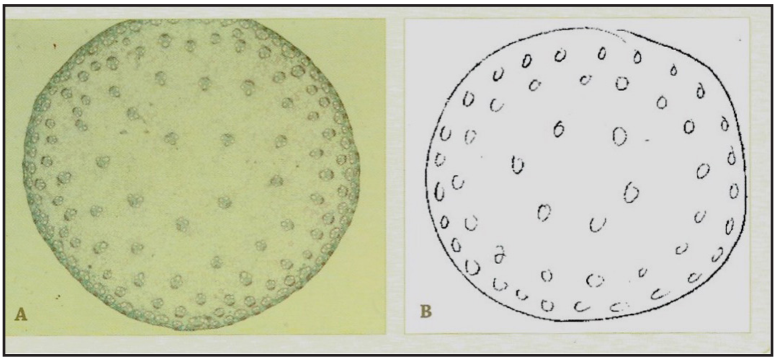


Figure 5. *(A) Cross-section of maize stem. (B) Student sketch of A.*

the vascular bundles of monocots stems as being "scattered throughout the ground tissue" (Urry et al., 2023 [p. 768]; Raven et al., 2023 [p. 778]). Figure 5A is a photomicrograph of a maize stem that I put on the screen for the class. I then ask them to observe it carefully and make a sketch, filling a full page of their notebook, of the general tissue regions they observe. I circulate through the class with a blank overhead transparency sheet observing the student sketches, but with no comments. When I find one that clearly shows some patterns, I'll ask that student to trace her sketch on the overhead sheet. Figure 5B is a typical example. As a class we'll then go through the sketch noting any observed patterns, labeling parts, and adding additional patterns observed by other students.

Students often recognize at least six patterns: (1) concentric rings of bundles, (2) bundle density greater in outside rings than interior ones; (3) bundle size greater in interior bundles than outside ones, (4) bundles seem to alternate from one ring to the next, (5) there is noticeable cell differentiation within bundles, and (6) bundles always orient in the same direction relative to the surface, regardless of where they occur in the stem. A close-up photomicrograph (Figure 6) makes it easier to see cell differences within a bundle. A last question, which they'll turn in on a ¼ sheet of scratch paper, is: Which direction is the nearest epidermis in Figure 6: **left**, top, right, or bottom? How do you know? Students identify definite patterns of bundles within the stem; they are not simply "scattered." In fact, they are precisely arranged, and studies of serial sections can predict which bundle of which leaf, up and down the stem, every one of these stem bundles will supply (Pizzolato and Sundberg, 2002).

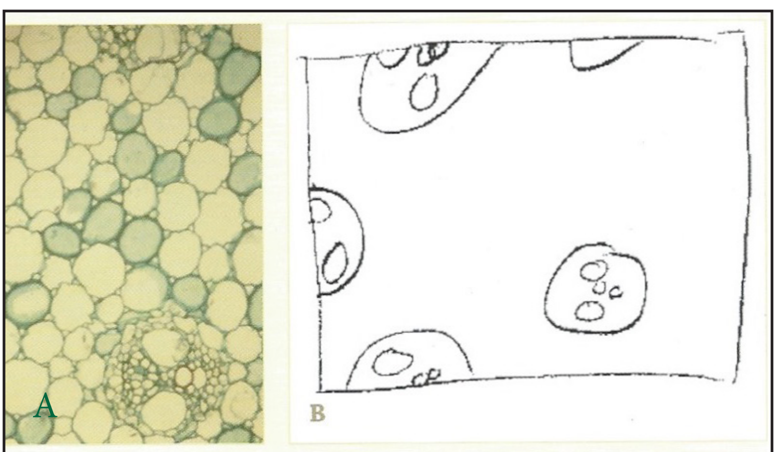


Figure 6. *(A) Magnification of portion of Figure 5A. (B) Student sketch of A.*

Plant Migration on Mountains and Climate Change

This is another example from "Inquiring about Plants" (pp. 135-146). In brief, Humboldt suggested that the change in plant communities, as elevation increases in the mountains, is similar to that observed with increasing latitude on Earth. We also know that the combination of average temperature and average precipitation in a region allows us to predict the plant communities (biomes) that will be present. Given the warming associated with climate change, what would you predict will happen, over time, to the various plant communities occurring on the sides of a mountain? It seems obvious that as the climate warms, plant communities will migrate to higher elevations.

The data in Table 1 show the average change in elevation for 73 tree species in the Coast Range of Northern California since the 1930s. Do the data support your prediction for the effect of climate change? Why or why not? What other factor most likely accounts for the unexpected decreased elevations in so many species? Hint: go back to the two factors we know we can use to predict plant communities/biomes we will find in an area.

Table 3.2 Elevation change, positive or negative, in meters. (From Crimmins et al., 2011)

Species	Elevation	Species	Elevation
Abies concolor	-25.1	*Lithocarpus densiflorus*	-492.7
Abies magnifica	147.0	*Lotus scoparius*	-
Adenostoma fasciculatum	-12.9	*Monardella odoratissima*	-
Aesculus californica	-433.6	*Pinus albicaulis*	-
Amelanchier alnifolia	-276.8	*Pinus attenuata*	284.2
Artemisia californica	-	*Pinus jeffreyi*	86.1
Arctostaphylos glauca	41.4	*Pinus lambertiana*	-176.8
Arbutus menziesii	234.3	*Pinus monticola*	-416.3
Arctostaphylos nevadensis	-197.0	*Pinus ponderosa*	70.8
Artemisia tridenta	-253.7	*Pinus sabiniana*	-119.7
Arctostaphylos viscida	-100.8	*Prunus emarginata*	-36.7
Baccharis pilularis	-	*Pseudotsuga menziesii*	239.0
Calocedrus decurrens	-80.0	*Pteridium aquilinum*	744.2
Ceanothus cordulatus	214.4	*Purshia tridentata*	-316.3
Ceanothus cuneatus	-129.9	*Quercus agrifolia*	-
Ceanothus integerrimus	-160.6	*Quercus berberidifolia*	667.7
Cercocarpus ledifolius	-711.7	*Quercus chrysolepis*	-94.9
Cercocarpus montanus	-76.0	*Quercus douglasii*	-30.4
Ceanothus prostratus	-20.6	*Quercus durata*	-156.8
Ceanothus velutinus	-270.7	*Quercus garryana*	-31.0
Chrysolepis chrysophylla	-439.7	*Quercus kelloggii*	-37.0
Chamaebatia foliolosa	23.7	*Quercus lobata*	-
Chrysolepis sempervirens	211.2	*Quercus vacciniifolia*	-93.5
Corylus cornuta	-276.4	*Quercus wislizeni*	-
Cornus nuttallii	-285.3	*Rhamnus crocea*	483.6
Eriodictyon californicum	-61.5	*Rhamnus ilicifolia*	-232.3
Eriogonum fasciculatum	61.4	*Rhus trilobata*	160.2
Ericameria linearifolia	-59.9	*Ribes roezlii*	247.0
Ericameria nauseosa	-313.9	*Salvia leucophylla*	293.6
Frangula californica	-	*Symphoricarpos mollis*	-690.7
Fraxinus dipetala	-100.4	*Toxicodendron diversilobum*	162.7
Garrya fremontii	-154.4	*Tsuga mertensiana*	-255.1
Heteromeles arbutifolia	-53.1	*Umbellularia californica*	-558.2
Hesperoyucca whipplei	-130.6	*Vaccinium ovatum*	-186.8
Juniperus californica	-151.5	*Vaccinium parvifolium*	-206.9
Juniperus occidentalis	-745.1	*Vulpia myuros*	-13.7
		Wyethia mollis	-352.6

Table 1. *Change in elevation of 73 montane tree species in the Coast Range of California. Highlighted numbers are statistically significant changes.*

Size and Distribution of Stomata in Desert Plants

My final example is an extension of the stomata section of "Inquiring about Plants," where we ask is there a relationship between the number of stomata and the environment of the plant (pp. 45–47)? It seems logical to predict that there is a decrease in stomatal density with increasing drought and that stomata should be restricted only to the lower surface of leaves in desert plants. One of my early students in freshman botany tested this for his independent class project and got some unexpected results. I followed this up with a grant to work at the Desert Botanical Garden near Phoenix (Sundberg, 1986). In fact, three-fourths of the 111 species examined were amphistomatic, and only semi-woody xerophytes had a higher frequency on the lower (abaxial) surface than the upper surface (Table 2). Leaf and stem succulents did have the lowest stomatal densities, but they also, unexpectedly, had the largest stomata (Figure 7). Some seasonally dehiscent desert trees had more than 500 stomata/mm^2. In summary, classroom inquiry can not only improve students' understanding of the scientific concepts we teach but sometimes their naïve, unbiased, observations can uncover new connections and expand our understanding of science.

Ever since Bill Muir forced me to be an active learner through inquiry, I have used this approach in my own teaching and learning pedagogy. I particularly focus on common misconceptions held by many students (and the general public) and challenge them with data supporting more sophisticated understanding and a philosophy of lifetime learning (Sundberg and Moncada, 1994).

POSITION OF STOMATES ON LEAVES OF DESERT PLANTS. PER CENT OF TOTAL FOR LIFE FORM IN PARENTHESES

Life Form	Amphistomatic				Hypo-stomatic	Total
	Adaxial Pre-dominant	Abaxial Pre-dominant	Isostomatic (incl. Cylindrical)	Total		
Seasonally Deciduous	8 (25)	8 (25)	6 (19)	22 (69)	10 (31)	32 (100)
Semi woody	1 (9)	3 (27)	4 (36)	8 (72)	3 (27)	11 (99)
Drought Deciduous	3 (23)	2 (15)	2 (15)	7 (53)	6 (46)	13 (99)
Leaf Succulent	6 (21)	4 (14)	13 (46)	23 (81)	5 (18)	28 (99)
Green Stem	2 (22)	2 (22)	4 (44)	8 (88)	1 (11)	9 (99)
Evergreen	2 (17)	3 (25)	4 (33)	9 (75)	3 (25)	12 (100)
Ephemeral	1 (17)	1 (17)	4 (67)	6 (101)	0	6 (101)
Total	23 (21)	23 (21)	37 (33)	84 (75)	28 (25)	111 (100)

Table 2. *Position of stomates on leaves of desert plants.*

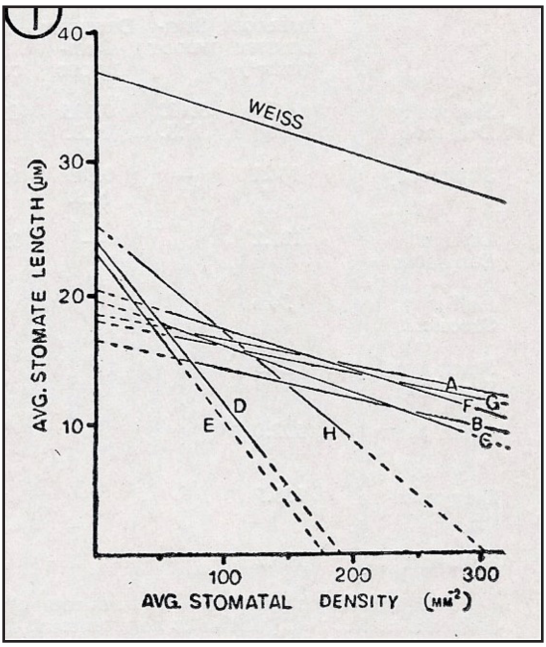


Figure 7. *Trends of stomatal lengths on stomatal density for various life forms of desert plants: (A) Seasonally deciduous; (B) Semiwoody,; (C) Drought deciduous; (D) Leaf succulent; (E) Stem succulent; (F) Green stem; (G) Evergreen; (H) Ephemeral. WEISS shows trend of temperate mesophytic plants.*

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Don't Forget Our Roots: Learning with Drawing


By Stefanie M. Ickert-Bond[1] and Brett C. Couch[2,3]

[1] University of Alaska Museum of the North, Herbarium, and Department of Biology and Wildlife, University of Alaska Fairbanks, 1962 Yukon Dr., Fairbanks, AK 99775, USA

[2] University of British Columbia, Departments of Botany and Zoology, 3156-6270 University Blvd, Vancouver BC V6T 1Z4, Canada

Thesis and Philosophy

"'If one painted a flower the size it is, nobody would look at it. When you take a flower in your hand and really look at it,'—and she cupped a strong, exquisite hand and held it close to her face—'it's your world for the moment. I want to give that world to someone else. Most people in the city rush around so they have no time to look at a flower. I want them to see it whether they want to or not.'"

Georgia O'Keeffe
(in an interview with Mary Braggiotti [1946])

How can we encourage our students to look at plants like Georgia O'Keeffe did? Slowing down, taking time to really look at plants, being a careful observer of the living world, appreciating their beauty and instilling curiosity to look, notice, and go back for more.

Unfortunately, we learn or are taught impediments to learning and curiosity. Do you remember the first time you made a drawing of a flower or picked a bouquet of dandelions? Did you stop drawing because you were not an artist? Did you stop collecting dandelions because they are "just weeds"? We urge teachers of botany to both remember our roots, the joy of discovery, the historical and contemporary importance of drawing in teaching botany, and to further explore fine-arts practices outside of traditional botanical drawing. To rekindle curiosity and the excitement of exploration of the botanical world, we propose that students should be encouraged to value the process not just the product: make it fun.

The use of drawing, painting, and illustration has a long history in botany for a very good reason; to draw or paint something, you need to look carefully. Although Leonardo Da Vinci is well known for his painting, Mona Lisa, he also studied human anatomy and botany. His approach to science was observational, and he filled sketchbooks and journals with detailed observations to understand the world he observed such as his study of *Ornithogalum* sp. and other plants (Figure 1A). His journals also illustrate how he used drawing as part of his thought process as an artist and inventor. In one example he created analogies between the leaves of plants and the forces of water in the water eddies (Figure 1).

Our philosophy is that students need to be trained to look first and look again, again and again. Discover the joy of looking and discovering; handling and dissecting plants, exploring and documenting local flora, and doing fieldwork provides context for other observations. We want students to develop observational skills as a habit of mind. We want to train students to deal with the reality that nature is messy and realize that perfect drawings from a textbook rarely capture the diversity they will encounter when observing plants or other features of the natural world. The challenges of observing nature and the insights gained from careful observation are also highlighted in Da Vinci's study of moving water. He observed and described the three-dimensional nature of flowing water, and developed the idea that turbulent flows consist of a range of co-existing eddies, varying in scale from large to small (Figure 1B)—but it was not until 1941 that this concept was mathematically formalized by A. N. Kolmogorov as the "cascade model of turbulence" published first in Russian (1941) with an English translation not appearing in print until 1991.

One of our classical mentors is Charles Edwin Bessey, who created the first undergraduate botanical laboratory in the United States, used and encouraged drawing in teaching, and had students draw from collected specimens in the lab. His motto was "Science with Practice," and he expected students to learn for themselves. A quote from his 1896 book *The Essentials of Botany* illustrates how he expected drawing to be used as part of learning about plants (Figure 2):

> "*In the use of this book I must urge that it is intended to serve as a guide only to the teacher and student. The student must actually see as much as possible of what is here brought to his notice. The book simply marshals in logical order the objects to be studied …. the young botanist should not be content to obtain all his facts at second hand; he must see with his own eyes all that may be seen*" (Bessey, 1896)

From here we hope to inspire you to explore other approaches to using drawing in your classes.

Figure 1. *Drawings by Leonardo Da Vinci. (A) Star of Bethlehem* Ornithogalum *sp., and other plants c.1506-1512. Wikimedia Commons. (B) Studies of water passing obstacles and falling, c. 1508-1509. Wikimedia Commons.*

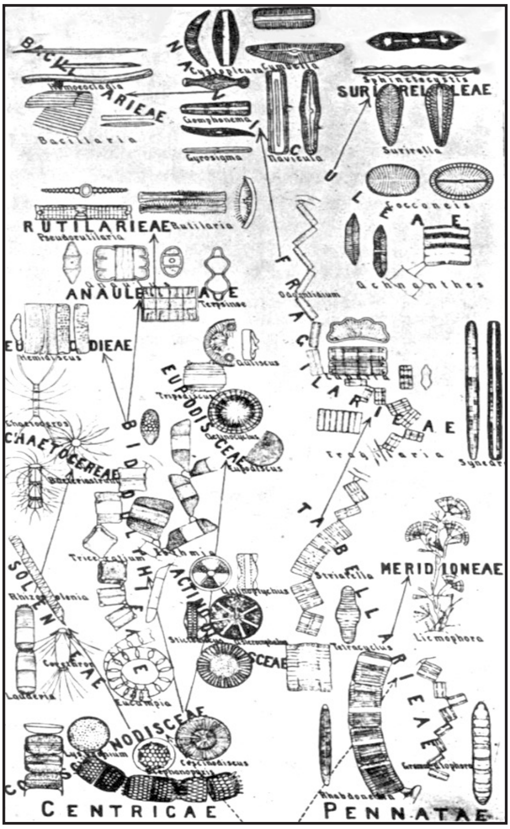

Figure 2. *Illustration of Bessey's classification of diatoms (Bessey, 1900).*

How Instructors Use Drawing in Teaching

From our own undergraduate education, we enjoyed the instructors who gave us time to appreciate botany, those who slowed down instruction by using drawings, and those who encouraged us to explore the subjects carefully and record our observations. Lectures in our undergraduate botany courses consisted of the professor using vertical-sliding chalkboards that were each filled with botanical drawings to illustrate the lecture content and were available to review after class. Unlike listening to a lecture or viewing a static image—activities in which students passively absorb information—these interactive, progressive, drawings actively engage students to record the lecture content. Today, we continue this tradition, with some added tech; as instructors we make use of drawings in our teaching to illustrate plant structures and convey information about taxonomically important structures. We try to create classes that are both engaging and foster slowing down and looking. The Learning Glass or Lightboard platform is a high-tech version of drawing on the blackboard, but with a technological twist. It creates a visual connection with the instructor who makes these Learning Glass lectures particularly engaging. During the use of the Learning Glass, a large piece of glass ringed by LED lights, the instructor stands behind the glass and uses fluorescent markers to draw on the glass, and the ink catches the light from the LED and glows clearly. The Learning Glass software collapses the perspective of the viewer and presenter into one shared perspective, allowing students to view the instructor in real time drawing and communicating with them, while getting visual and textual reinforcement of content (e.g., interactive progressive drawing). Students presented with classes using the Learning Glass had better knowledge retention over the same timescale as content delivered through PowerPoint (Hennige, 2020). Research has also shown that making drawings or sketches increases retention of information compared with taking in class written notes (Fernandes et al., 2018; Higley et al., 2024); in botany, which uses a lot of specialized terminology, drawings paired with terminology are particularly valuable for helping students retain information presented. Drawings need not be artistic—instead the drawing process is the main educational benefit of drawing, which Higley et al. (2024) elaborate on in their "Value of Bad Drawing in Teaching." We recorded many Learning Glass lectures for BIOL195 - Introduction into Flora of Alaska at the University of Alaska (Ickert-Bond and Kaden, 2022) and have made these available on Botany Depot (see Appendix) and on our class website (https://introtoflora.community.uaf.edu/module-1/).

What Do Students Do: Drawing in Labs and in the Field (or "A Pencil Is the Best of Eyes")

The first step in learning to observe is to slow down and take time. As Georgia O'Keeffe noted, people, like our students, are busy and often don't take time to look. One approach we have found that sets the stage for practicing slowing down and looking is to take students out of their comfort zone of the science lab and into an art gallery. Students are led through a slow looking activity using the Visual Thinking Strategies framework (Yenawine, 2013) with artwork that is chosen specifically because it is visually complex and something that students haven't seen before. This puts all of the participants on the same level in terms of experience with the work and so they cannot easily draw on previous knowledge or preconceptions. Students spend approximately 30 minutes looking at a work and responding to the prompts: (1) What do you see? (2) What makes you say that? and (3) What else do you see? This activity sets the tone for the entire semester in the lab. Students are then introduced to a variety of drawing and sketching activities that are typical in studio arts classes and that are intended to practice observing rather than producing finished drawings. An example is gesture drawing (Figure 3A–B). This is a very fast, timed, drawing of a subject—typically 15 to 60 seconds. Students are given various objects (pinecones, fern leaves, flowers) and given only 15 to 60 seconds to quickly capture as much of the object as possible. The drawings often look like scribbles; the purpose is not to capture a realistic representation, but rather to practice seeing the entire thing and recording some general features or ideas. A second type of activity is blind contour drawing, a slow looking activity. The idea here is to take a longer period (10–30 minutes) and slowly "trace" the contours (edges of a subject). The observer needs to convince themselves that the pencil is actually touching the edge of the object as they slowly move the pencil over the paper to draw the contour (Nicolaïdes, 1975). The catch here is that the student is not to look at the paper while they are drawing. The entire focus is on the contour of the object. By design, the drawing will not be a perfectly accurate representation of the object being drawn—the drawings are often rather funny—but the purpose is not a completed drawing, but to practice focused observation. Through the term, students will also practice the manual dexterity skills required for making drawings by doing simple doodles and activities that focus on making different types of marks. Each lab period begins with a doodle activity and some activity that focuses on some specific element of observation—layered drawings to show movement or sequential observations (Figure 3D). (Couch et al., 2023). Students then apply these skills to making sketches of microscopic structures or organisms.

We see that the skills of summarizing, simplifying, and observing, practiced with various drawing activities, provide an inroad to further development of visual literacy in students. For

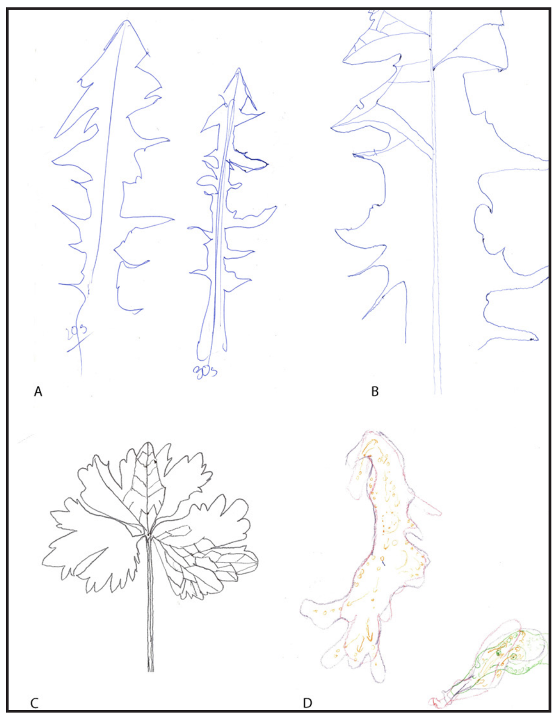

Figure 3. *Examples of different drawing and sketching techniques by Brett Couch (2023). (A) Gesture drawing of dandelion, (B) details added to part A, (C) detail drawing of leaf venation, and (D) layered drawing of amoeba.*

example, the ability to interpret and comprehend visual information in the sciences like graphs, figures, models, and diagrams increased by: (1) using sketches to develop or communicate ideas, and thinking through problems like diagramming an experimental design, or making predictions about patterns of data consistent with a particular hypothesis; (2) using visual media to communicate effectively in the form of figures or graphical abstracts; and (3) providing a mechanism of visualizing abstract concepts such as a gene on a chromosome.

Multiple authors have recognized the value of drawing across biology and STEM for communication and learning (Waldrip et al., 2010; Ainsworth et al., 2011; Landin, 2011; Tyler et al., 2018). Landin (2013) summarized the importance of drawing: "It's weird how much visual information I miss until I draw an object. Our brain just skips over details that don't fit with our preconceptions. When we draw, we have to include everything—and that leads to learning."

We encourage you to think about ways of creating experiences for your students that engage them to use drawing iteratively and repeatedly, and in ways that promote curiosity, thinking, and learning—to reveal the joy in slowing down and making a flower, a leaf, or a whole plant their world for a moment.

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Appendix

I. Talk at the Bessey Symposium at Botany 2024 in Grand Rapids, Michigan

- The Google Slides can be found at:https://docs.google.com/presentation/d/10YNrZVBC0pA2JLgRLYG- e cumqrZ5lVEIZsAUqt1ME7uU/

II. Learning Glass Lectures (LGLs)

- Most LGLs can be found on the BIOL190-Introduction to Alaska Flora website, under the individual modules, here are those for module 1: https://introtoflora.community.uaf.edu/module-1/
- Angiosperm life cycle: https://media.uaf.edu/media/t/0_lxrrkn0o
- A complete listing of LGLs can be found on Botany Depot https://botanydepot.com/2020/03/13/online-course-intro-to-alaska-flora-by-stefanie-ickert-bond/

Four new LGLs were completed in spring 2024:

- Bryophytes Versus Lichens Comparison https://media.uaf.edu/media/t/1_0k9hwi0o
- How to ID Mosses - https://media.uaf.edu/media/t/1_d75j0o1k
- Life Cycles of Bryophytes and Lichens https://media.uaf.edu/media/t/1_b7j7ba5i
- Basic Lichen Biology - https://media.uaf.edu/media/t/1_avubjnps

III. Virtual Herbarium

- https://www.thinglink.com/scene/1406090479749038081

The Two Rules of Great Teaching: Present with Enthusiasm and Make Your Students Do the Work

By Bruce Kirchhoff
Emeritus and Adjunct Professor of Biology, University of North Carolina, Greensboro, NC

There are two aspects to great teaching: The first and most important is to be yourself and to share yourself with your students in ways that enhance their learning. The second is to make sure that your students do most of the work. Learning these lessons took me almost 25 years of classroom experience and resulted in several major teaching awards, including the Bessey Award. I share my insights here in the hope that it will not take you quite as long for similar achievements.

The best way to share yourself in the classroom is to present with enthusiasm. Let your students see your love for your subject. Your enthusiasm will reach them better than any content you deliver. It sounds easy, but presenting with enthusiasm without losing intellectual focus takes practice. One thing that helped me to show my enthusiasm was to begin each lecture with a joke related to my course content. Since, at the end of my career, I most frequently taught Plant Diversity and Plant Systematics, all of my jokes were related to these subjects. What worked best for me was to find a visual joke related to the course content and present it at the beginning of class, just before I asked opening student-response questions. If I could not find a joke that fit the class, I created one. The jokes I chose were never wildly funny, but they were entertaining. For instance, I found this joke on the web: There is a picture of an abandoned car that is covered with ivy with the question, "Why are plants capable of consuming cars?" I would enthusiastically ask the class "Well, why?" After several wrong guesses, I would reveal the answer on the next slide: "Because they are auto-trophic." Occasionally a student would get this correct and I would react with joy, throwing my arms up and almost shouting "YES!" and maybe adding "Someone was paying attention in Intro Bio!"

I would often continue this light-hearted teasing during other parts of the class. For instance, my quizzes and exams always included a question on mitosis and miosis. Although I did not cover these subjects in my classes, I felt that the students should all have a basic understanding of the difference between mitosis and meiosis before they graduated. For some students these questions provided free points, but more than half the class regularly missed them. Right at the beginning of the semester, during the first lecture, I would say something like this: "You all learned about mitosis and meiosis in introductory biology. Some of you have had genetics, where you learned about them again. How many of you remember the difference?" (Maybe 2 people out of 24 raise their hands.) "That is what I thought [said with great humor]! Well, in this class you will have the opportunity to test your knowledge because every quiz, every test, and many clicker quizzes will have a question about mitosis and meiosis. For some of you these will be free points [said with enthusiasm]! That is great! I want to give you free points! However, for some of you these questions will be a source of never-ending frustration [said with a hint of sadness]. You will always be asking yourself, 'How did I miss that AGAIN?!' Take my advice. Review the difference between mitosis and meiosis so you are not pulling your hair out at the end of each quiz [I mime pulling out my hair and show them my bald head]. You see where this leads!" By miming pulling out my hair, I show the students that I am just as foolish as they are—that I have made all the same mistakes. This, and similar gestures throughout the class, gives the students permission to accept their own mistakes with grace, and even to laugh at them. I have found that this attitude does much more to enhance learning than any serious admonitions I might use.

Later in the class when I gave a clicker question on mitosis or meiosis and 60% of the class got it correct, I would enthusiastically congratulate them and then speak to the 40% of the class that missed the question. I might again mime pulling out my hair and remind them that these are supposed to be free points and that if they do not want to end up like me (I tap my bald head) then they should really review mitosis and meiosis. Then after class I might post some links to good review sites. Some students will continue to miss these questions no matter what I do, but even if they never learn the difference between mitosis and meiosis, the class atmosphere that I create with these types of interactions helps the students feel comfortable and encourages them to work hard.

Let me give another example of how I used enthusiasm and jokes to promote student learning. One fall break I went to the beach for a few days. While there I drew one of the life cycles we were learning in the sand and took a picture of it. That picture was the opening slide of the first lecture after break. The caption read "Why? What do you do at the beach?" (Figure 1). Although most of my students worked at least half time and had been working over break, this joke reminded them that they should not forget the class material

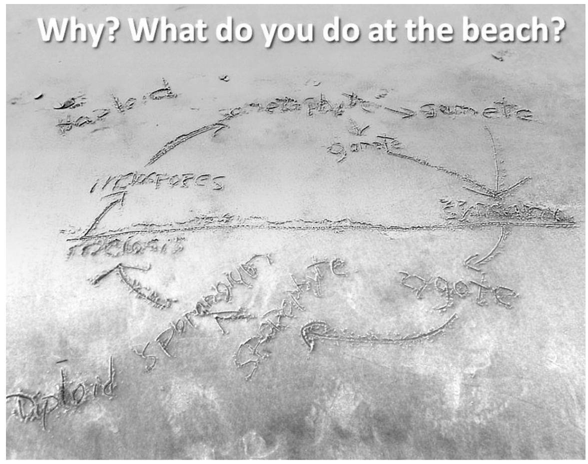

Figure 1. *A life cycle drawn in the sand.*

just because they were otherwise engaged. Jokes like this reminded them of the seriousness of the material without hitting them over the head with it.

Although there are many other ways to present with enthusiasm, I hope that these examples give you some idea of how I approached my class. You can see that there is a definite advantage to being bald. 🙂

This brings me to my second point: Make the students do the work. Presenting with enthusiasm creates a class atmosphere that is conducive to learning, but the students must still learn the material. The only way to do this is for them to do the hard work of learning. I believe that our task as instructors is to make this hard work seem like fun, at least as much as possible. I do not mean to minimize the work that the students have to do. I strongly believe that the only way to learn is through hard work. However, if the students will not do the work you assign, they cannot learn. An example of what could be an extremely effective learning method will make this clear. I call this the White Paper Method.

The White Paper Method starts with a sheet of blank paper, a pencil, and a copy of the material that the student wants to learn. This can be their lecture notes, notes provided by their instructor, or their textbook. Once the student has identified the material for their study session, they close their notes and take out the paper and pencil. They then recreate, with as much detail as possible, the material they want to learn. Let's say that they want to learn the life cycle of a vascular plant like *Pinus*. On their blank piece of paper, they draw the life cycle in as much detail as they can. It does not matter if they can draw only a small portion of the life cycle. Once they have done this as best they can, they compare their work to their notes and correct their work so that they have a perfectly drawn life cycle. It is best if they do this in a different color so they reinforce what they have yet to learn. Now comes the most important part. They take their corrected work and throw it away and take out a blank piece of paper. On this paper they draw the life cycle again. Since they just reviewed it, they will do a better job. When they correct this version as they did the first, there will be fewer corrections. If they have not gotten it fully correct, they repeat the White Paper process until they can draw the life cycle perfectly from memory. That ends this study session for this content. If they repeat this process at least one more time before the exam, they will ace any questions on this life cycle. The White Paper Method is extremely effective! I have had a student go from failing at midterm to a B in the class by using this method. That means she went from failing every test, to getting an A on every test. This is an amazing accomplishment.

The problem with the White Paper Method is that the students will not do it. The student I just mentioned was a soccer player and if she had failed my class she would have been kicked off the team. She was successful because of this incentive and because her coach made her use the White Paper Method. Most students do not have this incentive and, for whatever reason, will not use this method.

This is our conundrum as teachers. We must find a way to get the students to do the work that they are unable to do on their own. There are several ways I approached this problem. Perhaps some of them will appeal to you.

One of the most powerful ways of promoting student learning is to create effective homework. The archetype of effective homework is the White Paper Method, but we already know that students will not do this on their own. Can we fool them into doing it with creative assignments? One way I found to do this involves weekly in-class quizzes. In my Plant Diversity class, I expected the students to be able to draw even complex life cycles from memory. To get them to do this, I would first draw the life cycle with them in class, sometimes asking them to draw it from memory during the class period and then going over the life cycle with them as they corrected it on their papers. You will recognize this as the first iteration of the White Paper Method. To get them to continue the process at home, I would tell them which life cycles were candidates for next week's quiz. Early in the class there were few choices, but late in the semester there were so many that telling them that any life cycle was fair game would overwhelm them and they would do poorly. If I told them to expect one of the following three life cycles on next week's quiz, they would make sure that they could draw them from memory and the vast majority of the students would get full credit. This made grading very simple. I only needed to glance at a life cycle to see that it was correct. Grading could be done quite quickly. Over the course of a few weeks, I could cover all of the required life cycles with near-perfect performance. In this case I used in-class quizzes to create the incentive for students to do the work on their own.

As every teacher knows, one only really learns the material when one has to teach it to others. With this in mind, I began requiring my students to present some of the lectures in my classes. In Plant Systematics, the students presented almost all of the plant families. I presented a few at the beginning of the class to give them examples of what I expected, then the students took over, presenting the family characteristics for the rest of the semester. I gave them very explicit instructions on what to include (see links below), and most students did very well. To my surprise they did even better when they presented online during Covid. I suspect that this was because I allowed them to present with their cameras off, which relieved much of their anxiety.

When I taught Biological Evolution, I presented the first few lectures before turning the rest of the material over to the students. My approach to this material was unusual in that I had the student's present chapters from *The Origin* (1st ed), and a graduate text by Kemp, *Fossils and Evolution*. I found that Darwin spoke to the students in ways that contemporary texts could not. Darwin was writing to an audience that doubted the correctness of his theory. He wrote to persuade, not to present facts. This approach was much more meaningful to my students, many of whom came from religious backgrounds where they were encouraged to avoid any discussion of evolution. A fuller description of my approach in this class can be found at the following link: https://sites.google.com/view/active-learning-in-use/ .

Another great way to get students involved in a class is to have them take notes. For years I wondered how I could do this without requiring the students to turn in their notes, which would require an inordinate amount of grading. The Covid pandemic provided an opportunity to try a new method, with good success. I was teaching Plant Systematics when my university closed. Since the students presented many of the lectures in this class, I had to use synchronous class time for these lectures. To accommodate this, I decided to record my lectures and present them asynchronously. In order to ensure that the students were paying attention, I required them to turn in their notes using our course management system (Canvas). Most students took notes on paper and photographed them using one of the many phone apps created for this purpose. Many of my students used Genius Scan. I used a three-tier grading system for these notes: good (100%), needs work (50%), no credit (0%). After a few lectures I could show the students examples of good notes (with the note-taker's permission). Soon 98% of the students were getting full credit. This made grading very easy. In fact, I spent more time waiting for the digital files to load in Canvas than I did grading the student's work. Some of the notes were amazingly good. I still wonder if it would be possible to get students to take good notes in face-to-face lectures, but I never succeeded in this before I retired. Perhaps some variation on these procedures will work for you.

In closing, it would be remiss of me to fail to mention my work creating visual learning software. I will not go into detail about this software here because it is described more fully elsewhere (see links below). The software is free and Open Source. I tested it in the classroom and found it to be extremely effective (Kirchoff et al., 2014). Stephanie Jeffries at North Carolina State has created an online version and extension of this software for use in teaching plant identification. The links to her work are also below.

- **Active Visual Learning Software**: https://sites.google.com/view/image-quiz/home
- **Teaching materials for a course on Plant Diversity**: https://osf.io/69skm/
- **Plant Life Cycle Diagrams:** http://planted.botany.org/index.php?P=FullRecord&ID=578
- **Recorded lectures on Plant Diversity:** https://www.youtube.com/@plantdiversity
- **Recorded lectures on Plant Systematics**: https://www.youtube.com/@Plant_Systematics
- **White Paper Method**: https://youtu.be/Gyu4KQPekx0
- **Stephanie Jeffries ILEX (Identify-Learn-Explore) online tool:** https://sites.google.com/ncsu.edu/ncstatedendrology/ilex-study-tool?pli=1

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The Evolution of an Educator

By Suzanne Koptur
Professor Emerita, Florida International University

Growing up in Detroit and attending public schools, I thought I would become a doctor, lawyer, or writer. At that time, I had never heard of doing science for a career. But from my first Biology lab course at the University of Michigan, going on a walk outside looking at trees and insects, I discovered the great outdoors. In the end, I chose graduate school to let me continue doing just that.

Undergrad Days

My Botany education was fun and solid, with most courses delivered in the standard lecture format. The professors were talented lecturers, enthralling us with subject matter and amusing us with their personalities (Botany Professors Hiroshi Ikuma, Herb Wagner, Ed Voss; Zoology Professor Dan Janzen; Organic Chem with Professor Richard Lawton). I was a very good student and excellent note-taker, recording everything they said almost *verbatim*. Writing it all down helped me commit it to memory. Reading textbooks and papers, solving problems, and reviewing notes helped me succeed in almost every course. Some courses were less conventional. Dan Janzen's Habitats and Organisms course consisted of non-stop lectures, to a huge audience in a darkened room, while showing us beautiful slideshows of animals and plants from around the world. In John Vandermeer's Quantitative Ecology, we served as guinea pigs for his early textbook/workbook of problems (Vandermeer, 1981). Biochemistry used the self-directed "Keller Plan," taking tests on every chapter complemented with lectures on extra material. Field experiences in courses at the University of Michigan Biological Station and as a research assistant to Sally Kleinfeldt in the woods of New Hampshire let me see what research might be like. Although I also worked as a nurse's aide for two summers (one in Detroit at Plymouth General Hospital, the other at Mott's Children's Hospital), which gave me a view of the medical world, I chose the path that would be more fun, with perhaps less job security and money, but more time outdoors and doing things I loved.

I had work-study employment in the University Herbarium, working with Dr. Robert Shaffer to index the type collection of Fungi. I got some research experience with Dr. Rogers McVaugh, writing a Latin description of a newly discovered species of *Pedicularis* from Mexico (my first publication: McVaugh and Koptur, 1978). I wrote a senior thesis about extrafloral nectaries with a focus on aspen under the advice of Dan Janzen. During my undergrad time, I was lucky to be an assistant to Teaching Fellows (TFs as they were called, and we were TAs) in Practical Botany (taught at the Botanical Garden) and Plant Systematics on campus. Though headed in the Systematics direction, I shifted to Ecology because it seemed there was an endless supply of interesting questions to investigate. I received a Noble Fellowship from the Smithsonian Tropical Research Institute, doing my first tropical field work on Barro Colorado Island.

Graduate Studies in California: A Whole New Flora! (And Then Some!)

Entering grad school at Berkeley in the Botany Department as Teaching Assistants (TAs) in General Biology, we were required to take a weekly teaching seminar in addition to our twice-weekly TA meetings for General Biology, a two-quarter sequence directed by Dr. Bill Jensen. In the TA meetings, we learned the content and how to run the lab sessions, but in the seminar, we learned about good practices in science education. In my group of four TAs who all taught labs at the same time, two were grad students in the SESAME program (Search for Excellence in Science Education), which held a great appeal for me. Both suggested it might be best to stay in pure science, since I could always move to their field of science education later if I chose, but moving in the other direction might be harder.

After Gen Bio, I was a TA (with many others) for California Flora with Robert Ornduff, and a new basic botany course with Don Kaplan (along with fellow grad student Darlene DeMason). At Berkeley we taught labs, but we were also required to attend the corresponding lectures. I moonlighted as a note taker for the lecture courses in which I taught labs, for Black Lightning, a service run from a copy store where notes were copied and made available to subscribing students. I remember writing and typing them on mimeo sheets! I was unaware that this practice was controversial, as it evolved into some professors selling their lecture notes, etc. Nowadays (in fact, within the following decade), it is more common practice to provide lecture notes as part of the course materials for many professors.

I took some wonderful courses as a graduate student at Berkeley, including Evolutionary Ecology taught by Herbert Baker, who highly valued teaching as a pursuit. In that course there were students from many departments (Botany, Forestry, Zoology, Entomology), providing connections for all of us with other parts of the university. Herbert's lectures and demonstration labs were full of information, letting us take as much time as we wanted with his collection of articles, books, plant and animal examples, artifacts, etc. That was also the way he taught Economic Botany (see Baker, 1978). We solved problems using basic statistics and were expected to do a project of our own design. The field experiment I carried out at Tilden Park (taking the bus up into the Berkeley hills each time) was material for my first solo publication (Koptur, 1979). I learned a lot about prioritizing projects and publishing from James Hickman (thanks, Jim!), who had recently come to Berkeley with his wife, Carol Hickman. I also got to take the Organization for Tropical Studies' Tropical Biology course in 1977, a full immersion introduction to the neotropics, doing faculty-led group and student-initiated field projects for several months.

I then spent 2.5 years away from teaching as RA on a grant received by my major professor, Herbert Baker, and entomologist Gordon Frankie, to study Phenology and Pollination in the Costa Rican Cloud Forest, a wonderful time of my life (Koptur et al., 1988). After the field work was done, I returned to Berkeley to write up my dissertation on the plant/animal interactions of *Inga* and was again a TA, for Plant Systematics, and then was an RA in the University herbarium. My final semester I was asked to teach the Plant Ecology lecture and lab because the regular professor (Rob Robichaux) was on sabbatical. He graciously shared all his notes with me, and I got my first insight into preparing for lectures in the traditional way. With Suzanne Morse as my TA, we had an adventurous and very fun semester with lots of field trips and field exercises in interesting places.

Postdoctoral Work in the Midwest and Across the Pond

Completing my Doctorate in spring, and after unsuccessfully applying for many faculty positions in 1982, I took a teaching postdoc at the University of Iowa with Hank Howe, where I taught General Zoology labs and was in the company of some great tropical ecologists. This provided support (both financial and intellectual) while I wrote and published papers from my dissertation work and helped me get a NATO postdoc where I worked with John Lawton at the University of York, another wonderful time of my life. During these postdoc and early faculty times, I was also an investigator in the Naturalist-Ecologist Training Program during several summers at the University of Michigan Biological Station, a great experience for mentoring undergrads in independent research projects while pursuing my own research. I co-coordinated the Organization for Tropical Studies course in the summer of 1985 with my old buddy from undergrad days at the Michigan Biological Station, Bob Marquis—my first year as an assistant professor (see below).

Training Paid Off

All that teaching experience helped me get a job as an assistant professor at a young state university in Florida, Florida International University (FIU), where I was hired as a population biologist in 1985. I initially taught Gen Bio 2 and a graduate course in Evolutionary Ecology, as FIU was working toward an independent MS program. I later taught Introduction to Biological Research in our new graduate program and started teaching Ecology, then Plant Ecology in alternate years, along with workshops in Pollination and Field Techniques in Plant/Insect Interactions. I also stepped into Introductory Botany when David Lee and Jenny Richards moved on to other courses. I got some great ideas from workshops I took at the Botany meetings, including using portfolios in non-majors' courses (thanks, Joe Armstrong!) and great hands-on materials for groups, passing out sections of the same stem or tree branch (thanks, Stokes Baker!). I also participated in Project FIRST—Faculty Institutes for Reforming Science Teaching Through Field Stations—and was part of the FIU team for several iterations of this NSF-funded project. I had previously arranged field trips to Archbold Bio Station (Swain, 2019) for some of my courses, but this brought together a community of educators from different institutions in Florida to learn new approaches and design activities that could be used by all, especially in the field.

Time for a Change

After 10 or more years of delivering material in lectures, I was getting a little bored teaching in the same old ways. Enticed by a workshop at the annual Ecological Society meeting, I learned about Innovative Methods in Large Lecture Courses from two inspiring scientists and educators: Diane Ebert-May and Carol Brewer. That workshop was really life-changing for me! I learned how to foster more interactions with students and among students (Ebert-May et al., 1997). I realized that average attention spans are short, so that after 12–15 minutes of listening, most students were zoning out. By introducing active learning breaks that broke up the twice-weekly 75-minute classes into three or more sections, the students were engaged and got to talk and/or move around, breathing new energy into the lecture hall. I accepted the challenge and encouragement to transform my lecture courses, but one lecture/day at a time, and over several offerings of each course.

I was teaching Ecology every year, and so I took their advice with transforming this required course for all Biology majors. For three years I did an experiment with a different topic to see if active learning made a difference. The topics used in this experiment were Energy in Ecosystems (Spring 2006), Biological Communities (Spring 2008), and Adaptation and Natural Selection (Fall 2009). The content was not assumed to be comparable among the topics, but each served as a vehicle for the experiment. I had an ideal set-up for teaching the same material two ways, as half the class went to receive instruction from our science librarian about finding articles in the scientific literature, while the other half attended an Ecology lecture. I taught the same topic twice each time, but in two different ways.

To test the hypothesis that active student engagement results in greater learning, I used the following experimental design. All students in the experiment were to read the same textbook chapter and view the same material in the lecture that I delivered (i.e., the same PowerPoint slides), and each would write an in-class essay ("minute paper"). Students in the Active Learning group would have three in-class active-learning breaks during the lecture, e.g. a "think/pair/share," making a categorizing grid, concept map making, class modeling, human tableau, etc.—ideas I got from a great resource, my favorite education "cookbook," Classroom Assessment Techniques by Angelo and Cross (1993).

I could see which students attended the library session on each day, and which ones were present in lecture on the other day via the in-class essays they turned in. By using data from relevant questions on a pretest, from material on the topic in the mid-term exam, and then in the final exam, we saw that students who participated in the Active Learning version of the topic learned more and demonstrated this by better performance on the relevant questions on the mid-term exams (X1) than those students taught in the traditional way (Figure 1). There were greater gains for students in the Active lecture than for those in the regular lecture in the mid-term results (QX1 vs. Qpre). This difference did not hold up long term: performance on the final exam questions, QF vs. Qpre, did not differ significantly between those two groups. An interesting side result was that students who attended either type of lecture showed greater gains (by every measure except the mid-term exam) than those who did not attend

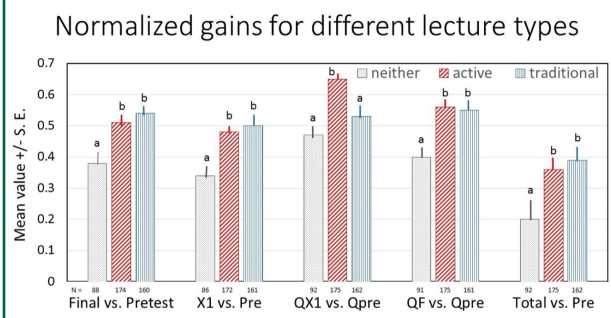

Figure 1. *Summary of outcomes for students attending traditional lecture (vertical striped bars) versus Active Learning lecture (diagonal striped bars) and those who did not attend lecture (empty gray bars). On the x-axis, Final = score on final exam, Pretest – score on Pretest, X1 = score on midterm exam in which the topic was covered, QX1 = score on questions on the topic on the mid-term exam (a specific part of X1), Qpre = score on questions on the topic on the pretest, and QF = score on questions on the topic on the final exam. Total = total score in course. Data are combined for three different topics in three different trials (semesters of the course), so normalized gain makes the results comparable among trials.*

lecture! I presented these results in a poster at a Gordon conference (organized by Gordon Uno) at Bates College, where it was energizing and inspiring to meet with science educators from all over. I continued to change my lectures in this class, and in others, over the following years.

Changes at the University

FIU created a STEM Transformation Institute (https://stem.fiu.edu/), in which I was one of a group of founding faculty fellows. We participated in many workshops on teaching and learning, assessment, and different ways of engaging and inspiring students. I learned more about active learning methods, starting with lab activities—presenting students with challenges and some materials, then letting them explore to answer problems. I learned about professors who simply did not lecture in class, rather using the lecture time to have students work together and independently on thinking and problem solving. A Learning Assistant Program was started, and grew, employing undergraduate students who had previously taken a course to help the professor manage group work in larger courses. We also adopted Peer-Led Teaching and Learning (PLTL) in many of the required majors' courses, where current students attend a weekly session led by a student who has previously taken and done well in the course. This intervention helped students do better than those who did not have PLTL as data from my Ecology courses show (Figure 2). Exam averages were higher for students taking PLTL along with the lecture course than those who did not (78.5 vs. 73.3), and substantially more passed the course as well (78.6% vs. 62.3). PLTL can help students from marginalized groups succeed in STEM majors (Sloane et al., 2021).

The Stem Transformation Institute also developed a Discipline Based Education Research group (DBER) that holds seminars biweekly throughout the semester—a great chance to learn from outside experts and others at FIU, and to interact with faculty in one's own and other departments. It connected those of us teaching science classes with science and math education colleagues and fostered collaborations, leading to many projects and publications. DBER meetings were enjoyable, and it was great to get to know others across the university who cared about teaching despite more praise for research accomplishments.

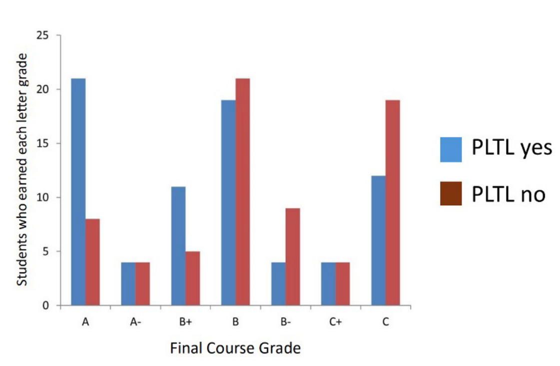

Figure 2. *The difference Peer-Led Teaching and Learning (PLTL) made in Ecology: participation of Ecology students in PLTL vs. Final course grade earned. PLTL yes = students who attended PLTL sessions; PLTL no = students who did not attend PLTL.*

Flipping Lecture: Fun and Beneficial for Students and Faculty

I decided to flip my courses, and this was an exciting time for me and the students (although some pre-med students worried they would not learn enough in my classes). Each class meeting had active learning almost all the time, working in groups with the supervision and help of Learning Assistants (LAs), presenting to others, and using white boards and other means of communication. Students were to prepare for each class by reading the assigned textbook chapter, listening to a couple of short PowerPoint lectures I had pre-recorded, and checking out (reading or listening to) other resources I posted online, and taking a quiz over the textbook chapter contents. We used clickers in class to provide instant feedback on multiple-choice questions, and then had students discuss questions and answer again. I started giving assessments (exams) in class using a two-part system: first, students would take the exam individually and turn in their answer sheets; then with their group they would work through the test and fill out IFAT (Instant Feedback Assessment Test) bubble cards. Each person's score was the average of the two. Attendance was very good because we always had activities and most of them "counted" as part of the students' grades.

Comparing student performance in my Ecology courses over all the years I taught the traditional way (lecture with no LAs) with the flipped course with LAs (taught only in the spring semesters) shows a marked improvement in course completion, passing rate (Figure 3A), and distribution of final course grades (Figure 3B). However, comparing the performance of students in two summer semesters of online Ecology (synchronous), one with and one without LAs, showed no difference (Figure 4); in fact, there were more high achievers without LAs.

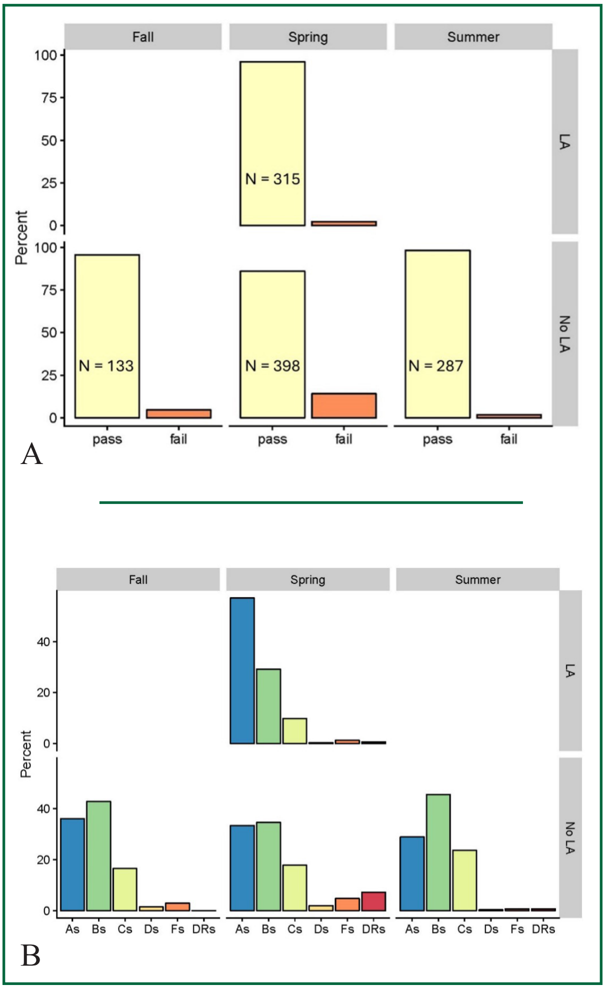

Figure 3. *Comparisons of the Ecology course taught flipped (with Learning Assistants, LA) versus traditional lecture (No LA). (A) Passing rates: multiple offerings over the years combined by semester, sample sizes for each given in the yellow bars; (B) Grade distributions in the same courses, including drops (DRs), sample sizes as in (A).*

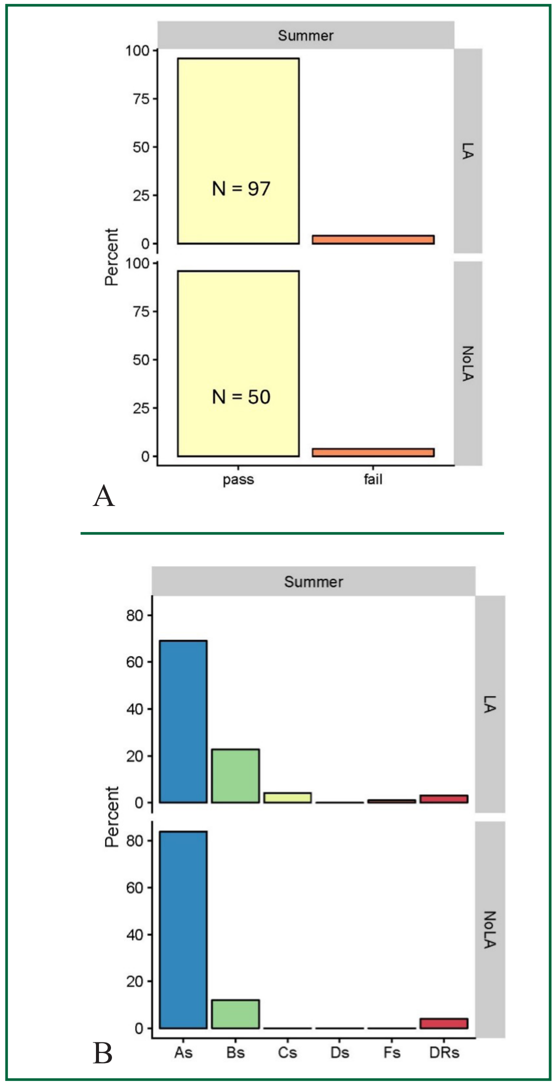

Figure 4. *Comparisons of the online synchronous Ecology course taught in flipped style with Learning Assistants (LA) versus more traditional lecture style without activities (No LA) over summer term offerings (initial summer class size was 50; the next time it was 97). (A) Pass/fail comparisons; sample sizes for each given in the yellow bars; (B) Grade distributions, including drops (DRs).*

Pre-Adaptation for Remote Teaching

When the pandemic struck and we switched to synchronous online teaching via Zoom, this flipped teaching format was easy to adapt, because lectures and quizzes were already online and the students were expected to go through the online materials and take the chapter quizzes before class. On Zoom, groups could work in breakout rooms with each LA visiting a subset of the groups. The groups (or a selected few of them) would then summarize or present to the entire class.

To meet community demands and enhance financial gain for the university, the College of Arts and Sciences wanted to develop a Biology BA degree fully online. Because I had taught Ecology many times, I volunteered to develop Ecology for this curriculum as asynchronous online. Each topic was covered by short lectures, activities to be done by one student, quizzes on each chapter, and exams that could be taken twice. I developed an online lab, using some SimBio resources and creating one third of the labs myself with help from the teaching assistants (thank you especially to Cleo Pimienta and Andrea Salas Primoli!). This course has become increasingly popular over time, as have other online offerings of required courses, allowing working students and parents of small children to do this on their own schedule.

Community Education

Along with university activities, I have always been willing to give talks and organize activities for the public by lecturing and holding workshops for plant societies, nature groups, elementary, middle, and high schools. Some examples include the "After School Gardening Gang" with elementary students, project PRIDE (Pine Rocklands in Dade Environments) at West Miami Middle School (teacher Lisette Perez Munoz received a Toyota Tapestry grant), and several projects with the environmental magnet at TERRA Environmental Research Institute. All have helped me to communicate better, learning how to reach students of different abilities at all levels. Working in groups, the students help and teach each other, with more positive results for all.

All of these changes have certainly transformed my teaching and students' learning over time. Most of the changes were gradual (breaking up the lecture with activities), but some were extreme (flipping the lectures in all my courses). This is kind of how evolution proceeds: gradual versus punctuated equilibria. I have always liked teaching and consider it an important part of a professor's job, even though FIU became more and more research and funding oriented over my decades there. Evolving my teaching by adapting my methods to a changing clientele has helped me retain my interest in and enthusiasm for teaching for over 40 years.

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SPECIAL SECTION

Art in the Botanical Sciences: Past, Present, and Future

Within the past year, the *Plant Science Bulletin* has published two special issues in the special anthology, Art and the Botanical Sciences: Past, Present, and Future (the Fall 2023 and Spring 2024 issues). These issues grew out of our first workshop on botanical art at Botany 2022 in Anchorage, AK, and the collected articles explored many facets of the importance of botanical arts.

We present two more articles that were unable to appear in those issues: "Illustrating Cretaceous Park: First steps toward a botanical field guide for the Hell Creek Formation" by Kirk R. Johnson and Marjorie Leggitt as well as "Reconstructing the botanical past: Art and paleobotany" by Edward J. Spagnuolo et al. We hope you enjoy these articles and encourage you explore the past special issues at https://botany.org/psbarchive/view/issues!

The SciArt Collective
Nicolette Sipperly, Stony Brook University • **Rosemary Glos**, University of Michigan
Kasey Pham, University of Florida • **Patricia Chan**, University of Wisconsin-Madison
Ashley Hamersma, University of Florida

Illustrating Cretaceous Park: First Steps Toward a Botanical Field Guide for the Hell Creek Formation

By Kirk R. Johnson[1], and Marjorie Leggitt[2]

[1]National Museum of Natural History, Washington, D.C.
[2]Boulder, CO

ABSTRACT

Fossil plants provide unique data that can lead to credible reconstructions of ancient terrestrial landscapes and ecosystems. This paper describes our process as we use art and science to reconstitute the vegetation of the last North American dinosaurs (with apologies to extant birds). Our art-science toolkit includes geology, sedimentology, palynology, precision excavation and censuses of fossil plant sites, accurate tracing of fossil leaves and flowers, comparative analysis with modern plant relatives, articulated reconstruction drawings of fossil material, construction of schematics showing floral architecture and phyllotaxy, application of traditional and not-so-traditional artistic methods, and the completion of botanical image plates. Scientifically accurate plant species portraits are then combined with similarly generated animal reconstructions, and geologically constrained topography and geomorphology to create plausible views of lost worlds.

The Dinosaur Renaissance began in the late 1960s with John Ostrom's discovery of *Deinonychus*, a wolf-sized predatory dinosaur with claws on both hands and feet, and Bob Bakker's lively renderings of agile and active dinosaurs. When Stephen Spielberg's Jurassic Park movie debuted in 1993, Ostrom's dinosaur was labeled *Velociraptor* and the film portrayed terrifyingly realistic animals. Paleoart had become "pop art," but there were other problems too. The paleobotanist played by Laura Dern complained that the protagonists needed the opinion of a paleobotanist, and she was right. While the dinosaurs of Jurassic Park were largely from the Cretaceous Period, the surrounding vegetation was simply that of modern Hawaii.

At the same time, as an artist-paleobotanist team, we were working on actual fossils from the Hell Creek Formation of North Dakota to reconstruct a true Cretaceous Park. The resulting diorama in the *Prehistoric Journey* exhibition that opened in 1995 at the Denver Museum of Nature & Science included a walk-through forest foliated with more than 24,000 plastic leaves, all of them based on actual fossil leaves (Johnson, 1996; Leggitt and Johnson, 1999). Never had a dinosaur diorama been vegetated with plants that were collected in direct association with the dinosaurs. The ten plant species we reconstructed for this diorama have gone on to be the plant palette for the Late Cretaceous and have been featured in many subsequent paintings, books, cartoons, dioramas, and video games. Continued excavation over the last 30 years has yielded a remarkably diverse Hell Creek flora with more than 300 species (Johnson, 2002)

We are now embarking on an effort to bring botanical reality to the vegetation that was the base of the food chain that produced *Tyrannosaurus rex*, the planet's greatest terrestrial apex predator. We plan to do this by focusing on a suite of the best Hell Creek Formation fossil leaf quarries that we have collected over the last 30 years. These quarries represent different stratigraphic levels on the 100-m-thick formation and different depositional settings including ponds, floodplains, riverbeds, and levees. These quarries were chosen because they have superb preservation, commonly yield complete leaves, and show high plant diversity. Each quarry will yield the data needed to reconstruct a specific time and place from the last 1.5 million years of the Cretaceous. In this article, we demonstrate how we reconstruct a single plant, *Cobbania hickeyi,* using an example from the "Licking Leaves" site, a pond deposit in Harding County, northwestern South Dakota (Denver Museum of Nature & Science locality 2703).

Materials and Methods

Leaves and other plant parts are typically buried in clay, mud, or sand in or near rivers and ponds and are preserved as compressions or impressions in claystone, mudstone, or sandstone. Subsequent uplift and erosion create the outcrops that are the source of fossil plants. During fossilization, original leaf organic matter is typically degraded or destroyed, leaving a leaf-shaped void in the rock. This fact is useful because the rock will break along this plane of weakness to yield imprints of both the top and the bottom of the leaf.

During fieldwork in 1994 in Dinosaur Provincial Park, Alberta, and in southwestern North Dakota, we collected two separate examples of a complete floating aquatic plant with a rosette of leaves that we interpreted to be inflated. Stockey et al. (2007) described this plant, named it *Cobbania corrugata*, and assigned it to an aquatic clade of the Araceae. In this paper, we reconstruct the closely related species, *Cobbania hickeyi* (Stockey et al., 2016), which was based on one complete plant and many loose leaves from the Licking Leaves quarry (Figure 1).

Close collaboration between artist and scientist is extremely important throughout the illustration process, and for this plant we relied on our colleagues Ruth Stockey and Gar Rothwell. Reconstructing a three-dimensional plant from a flattened and sediment filled fossil required both mental and physical models. To do this, the artist (M.L.) traced several leaf fossils, "restoring" each in its entirety, and paying close attention to shapes, margin, and venation (Figure 2A). She used the drawings to create and arrange paper and wire leaf models to view the plant from various perspectives.

Figure 1. *A single leaf* Cobbania hickeyi *as it was found in the Licking Leaves quarry. The inflated part of the leaf has lifted off to show the interior venation of the leaf.*

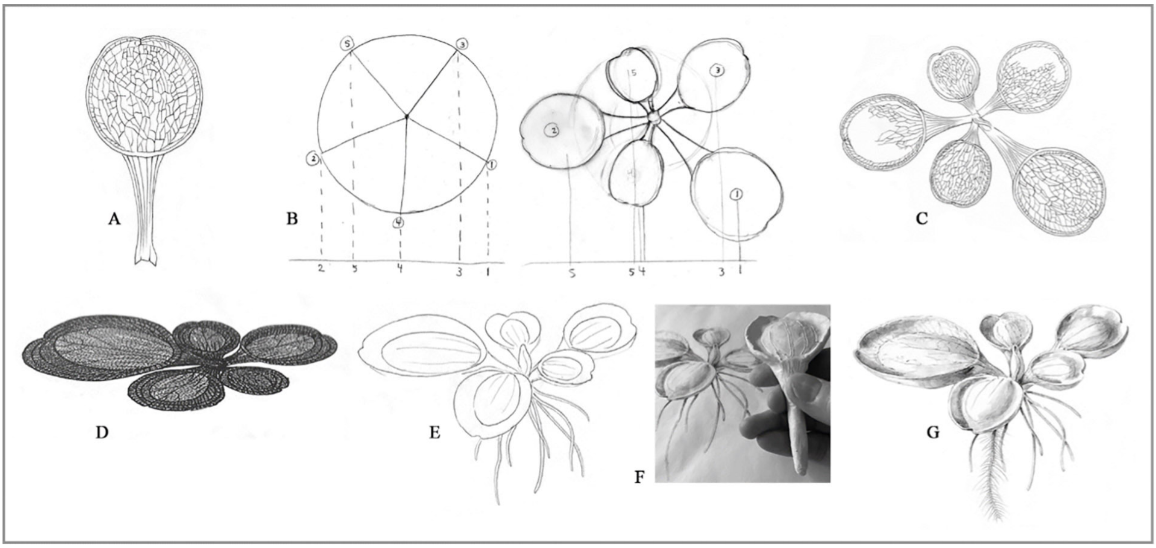

Figure 2. *(A) Tracing and restoration of leaf fossil. (B) Linear schematic of spiral phyllotaxy. (C) Delineated rendering of rosette. (D) Low-angle photo of inked illustration. (E) Pencil sketch of plant in oblique angle perspective. (F) Clay model helps to "see" how light falls on 3D leaves. (G) Value drawing with highlights and shadows to show form.*

The resulting top-down linear schematic illustrated the plant's spiral phyllotaxy, proper leaf size, and arrangement (Figure 2B). Using this sketch and referencing live specimens of *Pistia corrugata*, she fleshed out a detailed rendering of a plant rosette from above showing five leaves and a new leaf bud (Figure 2C).

A low-angle photo of the top view rotated the plant from a top view to a 3/4 view (Figure 2D), and the resulting image portrays the altered shapes and position of leaves in relationship to one another at an oblique angle (Figure 2E). Because the *Cobbania* leaves were inflated in life, it was useful to create a clay model to understand how they would appear while floating in water (Figure 2F). The clay model provides a physical form that facilitated the drawing of the leaves and petioles, both above and below an imaginary waterline. Shining a light on the clay models allowed the creation of a realistic interpretation on light on form (Figure 2G). The final drawing was transferred to watercolor paper where the artist used a living relative, *Limnobium*, for color reference to complete the painting (Figure 3).

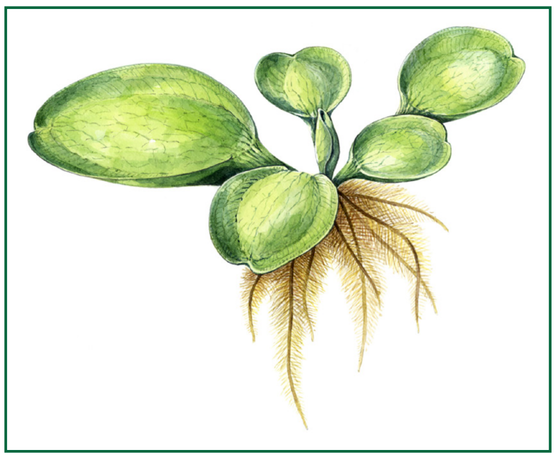

Figure 3. *Full-color reconstruction of the* Cobbania hickeyi *floating rosette.*

The dinosaurs of the Hell Creek Formation are surely the most illustrated animals of all prehistory. It is our goal to reconstruct the vegetation of their world with precision and beauty, one species at a time (Figure 4).

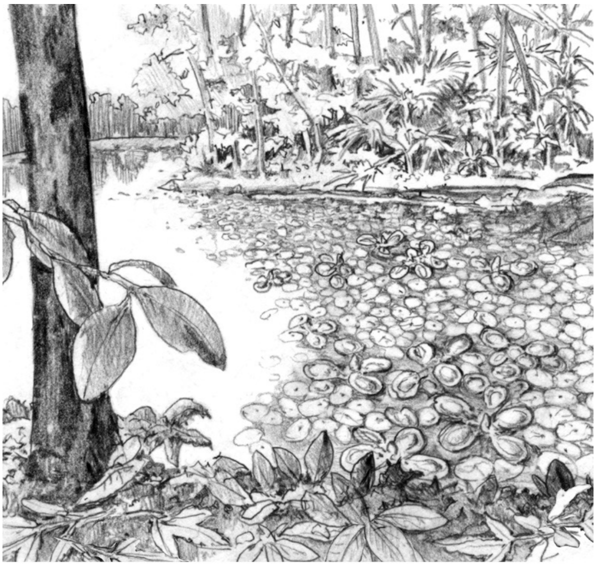

Figure 4. *Pencil study for a rendering of a Late Cretaceous pond environment with rosettes of* Cobbania hickeyi *floating in a shallow pond covered with of* Brasenia *(watershield).*

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Reconstructing the Botanical Past: Art and Paleobotany

By Edward J. Spagnuolo[1,5], L. Alejandro Giraldo[1], Mario Coiro[2,3], and Susannah Lydon[4]

[1]Department of Geosciences and Earth and Environmental Systems Institute, Pennsylvania State University, University Park, PA, USA.

[2]Department of Paleontology, University of Vienna, Vienna, Austria.

[3] Ronin Institute for Independent Scholarship, Montclair, NJ, USA.

[4]School of Biosciences, University of Nottingham, Loughborough, UK.

[5]Author for correspondence (email: spagnuolo@psu.edu)

ABSTRACT

Paleoart is an important tool for paleobotanists when reconstructing fossil plants and ancient ecosystems, and communicating with diverse audiences. Plants are fundamental components of terrestrial ecosystems. Thus, accurately depicting ancient plants in art is crucial for communicating comprehensive knowledge about ancient life. Here, we briefly review the history of paleobotanical art, discuss the challenges when accurately depicting plants in paleoreconstructions, and highlight recent works that reconcile isolated plant organs into scientifically accurate whole-plant and landscape-level reconstructions. Historically, paleoart has included plants as background elements in art featuring charismatic vertebrates, resulting in poorly depicted plants and ecosystems. Plant blindness—the phenomenon in which humans are more inclined to detect and appreciate fauna than flora—is a persistent problem for science communicators, botanists, and paleobotanists. Although plant blindness is rampant in 20th-century paleoart, modern paleoart that accurately incorporates and focuses on ancient plants can increase plant visibility in portrayals of the geologic past.

KEYWORDS

art, fossils, paleoart, paleobotany, plant awareness disparity, plant blindness, plant fossils, scientific reconstructions

Art is an important tool for scientists to engage with both scientific and general audiences (Lesen et al., 2016). Paleontological art—or paleoart—has been used to reconstruct extinct organisms and environments for almost 200 years and has influenced many of our assumptions about the past (Davidson, 2008; Stroud, 2008; Witton et al., 2014; Clary et al., 2022b; Manucci and Romano, 2022). Paleoart can also be useful to better understand and advance paleontological paradigms—most famously, the extensive updated paleoart that accompanied the Dinosaur Renaissance of the late 20th century (McDermott, 2020). Paleoart includes drawings and paintings, museum reconstructions and sculptures, as well as documentaries, movies, and even video games; here, we will mostly reference drawings and paintings, the most common form of paleoart.

Plants are fundamental for ecosystems and society, supporting biodiversity, terrestrial biomass, ecosystem structure, and as critical food and oxygen sources for humans and other organisms. Unfortunately, general audiences, policymakers, and other scientists are more likely to recognize and appreciate animals compared to plants. This disparity, termed *plant blindness* (also known as *plant awareness disparity* in recent years) has been attributed to reduced funding for plant-related projects compared to animal-focused research, as well as a global decrease in plant-centered education, conservation, and recognition (Wandersee and Schussler, 1999; Drea, 2011; Balding and Williams, 2016; Jose et al., 2019; Margulies et al., 2019; Parsley, 2020; Brownlee et al., 2021; Stagg and Dillon, 2022; Stroud et al., 2022; Walton et al., 2023).

Paleontology is widely thought of as a "gateway science" to other fields in science, technology, engineering, and mathematics (STEM), and as a way to teach broader audiences larger scientific concepts such as evolution, mass extinctions, climate change, and biodiversity (Moran et al., 2015). Often, these education and outreach initiatives include, or center on, paleoart (Burns et al., 2003; Clary et al., 2022a; Lipps et al., 2022). Additionally, plant fossils show how environments have responded to climate change, and knowledge of fossil history can be used as a rationale for the direct conservation of plants and ecosystems (e.g., the UNESCO World Heritage Gondwana Rainforests of Australia; Young and McDonald, 1987; Burnham, 2001; Wilson et al., 2011; Ivory et al., 2016; Lézine et al., 2019; Kooyman et al., 2020). Accurately representing fossil plants in paleoart is fundamental for conveying information about life in the past.

Paleoart has tended to focus on animals, with plants seen as a backdrop or scene-setting, rather than as "central characters" (however, see Benca et al., 2014; Sanders, 2014; Beans, 2022; Benca, 2022). Here, we discuss how plants have been depicted in paleoreconstructions over time within the context of plant blindness. We also consider the challenges facing plant paleoart and present promising trends for the future.

BRIEF HISTORY OF PLANT PALEOART

Duria antiquior ("A More Ancient Dorset"), painted by Sir Henry Thomas De la Beche in 1830 (Figure 1A), is widely considered the first example of a new genre of art: the reconstruction of life in the past based on scientific evidence (Rudwick, 1992, 2014; Lescaze, 2017). Although largely a marine scene, this first paleoreconstruction included palms and other less easily identifiable vegetation on background landmasses. In the lithograph versions, produced from De la Beche's work by George Scharf, fern-like and cycad-looking plants are also recognizable (Rudwick, 1992; Sharpe, 2022; Sharpe and Clary, 2022).

The circulation of lithographic prints of *Duria antiquior* began the proliferation of paleoreconstructions as a means of conveying information about life in the deep past to broad, non-scientific audiences from the 1830s onwards (Clary et al., 2022a), and these illustrations frequently incorporated detailed plant reconstructions (Vujaković, 2019; Manucci and Romano, 2022). Christian Hohe's final lithograph for Georg August Goldfuss' *Petrefacta Germaniae,* produced in 1844, is an exquisitely detailed scene from the Coal Measures with a key detailing the plant taxa, demonstrating that Goldfuss expected his audience to be as interested in them as in animal fossils (Rudwick, 1992).

The importance and ubiquity of coal in people's everyday lives (Yuval-Naeh, 2019), combined with popular interest in ferns and their allies (Whittingham, 2012), meant that paleoart focusing on Carboniferous plants was widespread in the latter half of the 19th century (Figure 1B). For instance, Carboniferous plants featured in Franz Unger's *Die Urwelt in ihren verschiedenen Bildungsperioden* ("The Primeval World in Various Developmental Periods") published in 1851, with artwork by Josef Kuwasseg, which inspired Edouard Riou's illustrations for Louis Figuier's *La terre avant le deluge* ("The Earth Before the Flood") in 1863 (Rudwick, 1992; Davidson, 2015; Vujaković, 2019; Collins, 2022).

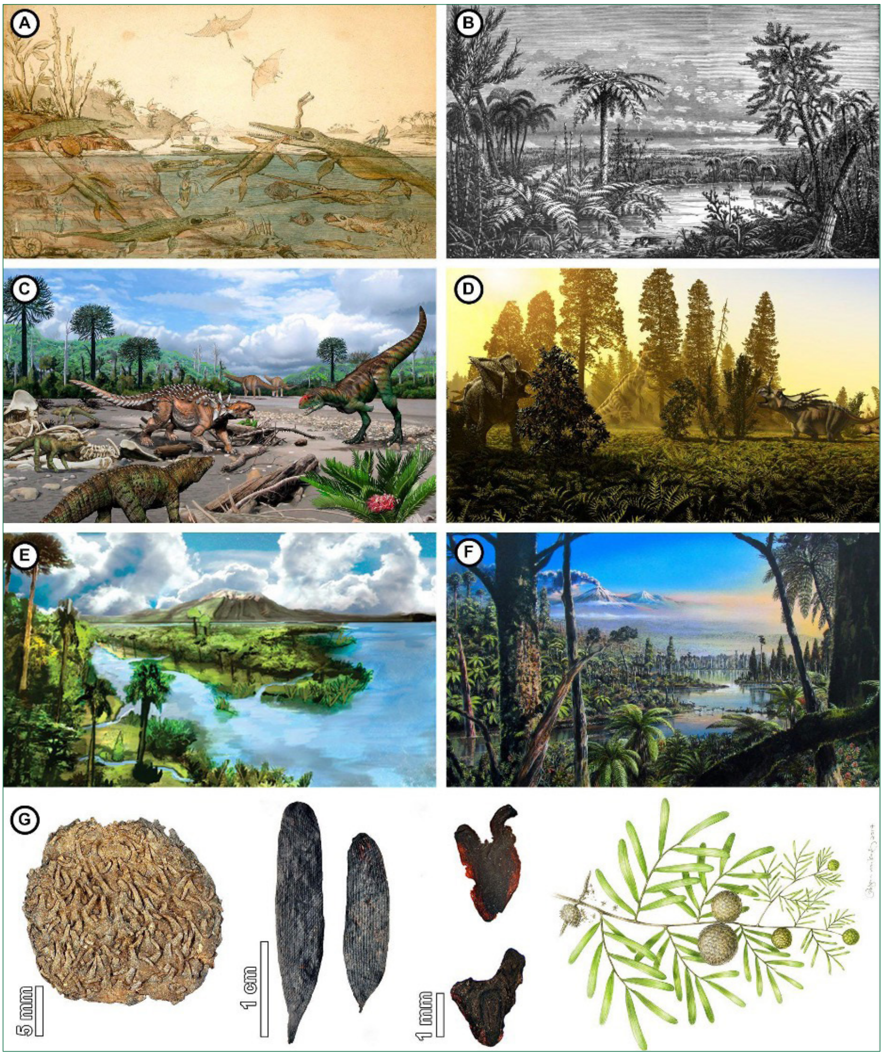

Figure 1. *Representative examples of plant paleoart throughout history and modern plant-centered paleoart. (A) Henry De la Beche's* Duria antiquior. *Note palms on the middle-right and some less easily identifiable vegetation on the middle-left. (B) Lycophyte, sphenophyte, and pteridosperm taxa from the Carboniferous of the United States depicted in Underwood (1896; artist unknown), in turn based on Dana (1874). (C) Dinosaur-centered reconstruction of the Late Cretaceous of Argentina, with some minor plant elements in the back (*Araucaria*) and front right (*Zamuneria*) (artist: Jorge Antonio González, modified from Paulina-Carabajal et al., 2021). (D) Dinosaur-centered reconstruction of the Late Cretaceous of Canada, with more prominent plant elements covering the ground (ferns), background (conifers), and with which the dinosaurs are interacting (angiosperms) (artist: Julius T. Csotonyi, modified from Mallon and Anderson, 2013). (E) Paleoenvironmental reconstruction of the Late Cretaceous of Argentina based on pollen data, which provides a more regional signature. Plants depicted include ferns, palms, and conifers (artist: F. Guillén, modified from Barreda et al., 2012). (F) Paleoenvironmental reconstruction of the mid-Cretaceous of West Antarctica based on pollen, geochemical, sedimentological, and organic biomarker data, providing a more accurate depiction of the landscape. Plants depicted included* Cyathea *(Cyatheaceae), Podocarpaceae, and Araucariaceae (artist: James McKay, modified from Klages et al., 2020). (G) Fossil material and reconstruction of the Early Cretaceous conifer* Krassilovia mongolica *and the associated leaf morphotaxon* Podozamites harrisii. *From left to right: Articulated seed cones, leaves, winged seeds; and reconstruction of a branch of* K. mongolica *reconciling all of the fossil elements including alternately arranged* P. harrisii *leafy shoots (artist: Pollyanna von Knorring, modified from Herrera et al., 2020).*

The "Classic era of paleoart" began in the 1890s in the United States with the hugely influential work of Charles R. Knight (Milner, 2012; Witton, 2018). Knight was famously commissioned to create paintings and murals for some of the largest natural history museums in the United States (including the American Museum of Natural History and the Field Museum). Often collaborating extensively with vertebrate paleontologists, Knight's murals centered on the charismatic extinct vertebrates at the forefront of paleontological discovery with naturalistic, but often homogenous, vegetation (Vujaković, 2019). However, Knight conducted detailed research on the Gilboa forests of New York and communicated with paleobotanist Winifred Goldring to maximize the paleobotanical accuracy of his plant-centered mural *Devonian Forest* (on display at the Field Museum; VanAller Hernick, 2003). Meanwhile, in Europe, Czech painter Zdeněk Burian painted lavish reconstructions including flora from Devonian to Quaternary times (Lavas, 2016; Witton, 2018).

Unfortunately, the paleoart of the mid-late 20th century pushed plants into the background. Dinosaurs and other charismatic vertebrates were the centerpieces of most paleoart from this time, and plants were rarely given much consideration. Monkey puzzle trees (*Araucaria*), cycads (Cycadales), *Williamsonia* (Bennettitales), palms (Arecaceae), and tree ferns (e.g., Cyatheales)—a very small fraction of the known fossil floral diversity—made up the majority of paleoartistic reconstructions of Mesozoic vegetation. The majority of known Mesozoic seed plants were rarely featured in dinosaur habitats and museum reconstructions of the time (Philippe et al., 2009; Sanisidro and Barrón, 2016; Herrera et al., 2020). Dinosaurs were often reconstructed standing on dry, lifeless earth with a handful of nondescript monkey puzzle trees in the distance, a plant-blind art style coined by Kirk Johnson as "monkey puzzles and parking lots" (Johnson and Troll, 2007; Figure 1C).

The rise of the Internet and digital art at the end of the 20th century enabled a paleoart community to develop and thrive online (Witton, 2018). Although tetrapod-centered approaches continued to dominate paleoart at the start of the 21st century (Figure 1D), some artists deliberately flipped this orthodoxy, such as Robert Nicholls in his reconstruction of the early Cretaceous Antarctic Peninsula (McKie, 2011), and influential practitioners such as Witton (2018) have advocated for far greater consideration of plants by paleoartists (Figure 1E–G).

CHALLENGES TO PLANT PALEOART AND THE POTENTIAL FOR SPECULATION

The fundamental challenge in paleobotany and plant paleoart is creating whole-organism reconstructions (Martine et al., 2019) given the fragmentary nature of the plant fossil record (Spicer and Thomas, 1986). The shedding and differential preservation of various plant organs—including leaves, wood, cones, flowers, spores or pollen, as well as fruits and seeds—throughout the plant life cycle result in a multitude of disarticulated fossils produced by the same plant (Dilcher, 1974; Kvaček, 2008; Wilf, 2008a; Manchester et al., 2014; Cleal et al., 2021), and whole-plant preservation is exceedingly rare (e.g., Boucher et al., 2003; Zamaloa et al., 2006). Additionally, these isolated fossil organs are often named as separate species (or even genera), which can be confusing for non-experts and paleoartists. For example, a single Carboniferous lycopsid tree could be the source of at least six separate fossil species if found in isolation (Spicer and Thomas, 1986). Similarly, the use of morphotaxa—species or genera representing a certain morphology rather than a biological unit—can be confusing for paleoartists (Figure 1G). For example, the wood genus *Araucarioxylon* and the leaf genus *Brachyphyllum* were produced by multiple conifer groups (Philippe et al., 2009; Philippe, 2011) but are often reconstructed as *Araucaria*, fueling their overuse in paleoart.

Although leaves are the most abundant plant macrofossils, leaf morphology can be highly variable and plastic, even on leaves of the same plant; most paleobotanists today use caution when taxonomically identifying isolated fossil leaves (Dilcher, 1974; Doyle, 2007; Wilf, 2008a; Spagnuolo et al., 2022). During the 19th and 20th centuries, numerous angiosperm leaves from the Cretaceous and Cenozoic were inaccurately assigned to extant genera and families, largely due to superficial similarities. This has led many paleoartists, especially during the 20th century, to include genera that were likely not present (such as *Quercus, Populus, Acer,* and *Salix*) in late Cretaceous and early Paleogene landscape reconstructions. Although reproductive organs—such as fruits, seeds, flowers, and cones—are the basis for most modern fossil plant taxonomy and identification, they are often more delicate and produced at much lower abundances than leaves (Gastaldo, 1992; Cleal et al., 2021).

When reconstructing ancient ecosystems, paleoartists must also consider the scale at which they are working. Compressed leaves have been shown to mostly represent a snapshot of local vegetation, with low levels of non-local influences (Burnham, 1994, 1997; Wing and DiMichele, 1995; Cleal et al., 2021). Conversely, pollen and spore data can represent regional vegetation from many habitats within a larger region (Behrensmeyer et al., 2000; Birks et al., 2016). When combined, these data can be used to accurately depict local (e.g., beside a pond) to regional (basin-level) vegetation (Figure 1E and F; Opluštil et al., 2014; Costamagna et al., 2018; Barreda et al., 2020; Wilf et al., 2022). When depicting ancient landscapes, paleoartists should also consult with scientists from other geological disciplines (e.g., sedimentologists) to understand the paleo-topography of the region and how that would influence the distribution of past vegetation.

While paleobotany deals with fragmentary evidence, illustrations often require a well-developed organismal concept, often based on comparative morphology or nearest living relative approaches (Witmer, 1995; Witton, 2018; Martine et al., 2019). The nature of the plant fossil record and the difficulties associated with reconstructing whole plants (Bateman and Hilton, 2009) imply a certain degree of speculation regarding the reconstruction of most plant fossils. Although the practice of representing "known unknowns" has become an important part of vertebrate paleoart (Conway et al., 2013; Nieuwland, 2020), paleoartists seem to be more cautious with plant reconstructions.

The reason for such caution could be a lack of accessibility to botanical and paleobotanical knowledge, as well as limited input from scientists. Since the late 19th century, paleoart has been driven by commissions, most often by vertebrate paleontologists, not paleobotanists. Scientists must provide artists with more paleobotanical information when possible; however, this can be a challenge because plants and animals require different environmental settings to fossilize and often are not found in the same rocks (Behrensmeyer et al., 2000). Navigating the jargon-rich botanical and paleobotanical literature can be incredibly difficult for non-experts, especially given the decrease in botanical education in general curricula over time (Drea, 2011; Stroud et al., 2022). Although botanical illustration is a well-established field with a rich history spanning centuries (Ben-Ari, 1999; Swann and Pye, 2019; Bienvenue and Chare, 2022), paleoartists rarely come from a formal background in botanical illustration (Sutton, 2019; Dart and Coiro, 2022; von Knorring and Coiro, 2022) and instead have more varied professional stories (Orr, 2019). The expansion of paleoart-focused education in traditional botanical illustration curricula might provide a way forward to better integrate these two fields.

THE FUTURE IS BRIGHT FOR PLANT PALEOART

Over the last 20 years, scientists have made massive advancements in understanding plant evolution and ancient ecosystems due to the advent of molecular data, mass digitization of natural history collections, and new imaging and statistical methods (Donoghue and Doyle, 2000; Bebber et al., 2010; *Amborella* Genome Project, 2013; Page et al., 2015; Coiro et al., 2019; Leebens-Mack et al., 2019; Bakker et al., 2020; Hedrick et al., 2020; Romero et al., 2020; Johnson et al., 2023). Plant paleoart has also made significant strides in accurately reconstructing ancient plants and paleo-landscapes (see art in Phillips and DiMichele, 1992; DiMichele et al., 2007; Benca et al., 2014; Hetherington et al., 2016; McElwain et al., 2021; Beans, 2022; Benca, 2022). Fossil discoveries worldwide have yielded additional fossil plants with connected organs, allowing for more accurate whole-plant artistic reconstructions (art in Sun et al., 1998, 2002; Hermsen et al., 2009; Zhang et al., 2010; Opluštil et al., 2014; Gomez et al., 2015; Bodnar and Escapa, 2016; Rothwell et al., 2022). Extinct plant lineages, which often lack whole-organismal concepts, are being reconstructed and properly included in landscapes (Philippe et al., 2009; Barreda et al., 2012; Wang et al., 2012a; Herrera et al., 2020). Cretaceous charcoalified flowers, and their incredibly detailed artistic reconstructions by Pollyanna von Knorring and others, have provided an unexpected window into early angiosperm evolution (Crepet et al., 2004; Schönenberger, 2005; Crepet, 2008; Takahashi et al., 2008; Friis et al., 2011). Fossil Lagerstätten, amber deposits, and insect damage found on fossil plants have been shown to document plant-insect interactions, including pollination, herbivory and palynivory, insect mining and galling, and insect-plant mimicry (Wilf and Labandeira, 1999; Wilf, 2008b; see art in Wang et al., 2012b, 2014; Bao et al., 2019; Correia et al., 2020; Cariglino et al., 2021; Tihelka et al., 2021; Xiao et al., 2021; Prevec et al., 2022).

Plants are emerging from the background of ancient ecosystems in modern paleoart. The *Ancient Colorado* and *Ancient Denvers* murals and related museum reconstructions accurately reconstruct the history of the Denver Basin based on decades of detailed stratigraphic, paleontological, and paleobotanical research and collaboration with artists and sculptors (commissioned by Kirk Johnson and the Denver Museum of Nature and Science, and brought to life by artists Jan Vriesen, Donna Braginetz, and Gary Staab; Johnson and Raynolds, 2006; Johnson and Stucky, 2006). These murals reconstruct ancient environments from specific fossil localities, instead of broad summaries of entire time periods that tend to depict plants and animals in the same reconstruction that did not actually coexist (common in 20th-century paleoart). Some of the exceptional plant-centered artwork of Smithsonian scientific illustrator Mary Parish includes the floristic turnover of the Carboniferous Rainforest Collapse and the vegetation of the latest Cretaceous (Montañez, 2016; Sutton, 2019). The murals of Jay Matternes expertly recreated the ecosystems of North America throughout the Cenozoic, detailing the diversification of modern mammal lineages and the rise of grasslands (Carrano and Johnson, 2019). By assembling detailed geochemical, stratigraphic, and palynological data, Klages et al. (2020) together with artist James McKay illustrated the once-diverse late Cretaceous polar forests of Antarctica (Figure 1F). Even traditional vertebrate-centered paleoart is often more conscious of the plant constituents than similar art 20 years ago (Figure 1D). In recent documentaries, video games (e.g., *Saurian*, Urvogel Games), and comic books, the vegetation is carefully considered to reflect the fossil record of the time period and region (Ehret, 2019; Parker, 2021; Clements et al., 2022; Wings et al., 2023).

Among the resources available for plant paleoartists, the Extinct Plant Paleoart Database (Jud, 2020) collects examples of published paleoart in an accessible and continuously updated format. The database currently includes 177 references to plant paleoart, as well as a separate list of plant paleoartists. Although the issue of paywalls associated with scientific journals still hinders full accessibility to paleoartists, this represents an important first step to increase visibility of available resources. We hope that these recent scientific and artistic advancements encourage paleobotanists to continue collaborating with artists in their research and engagement to reduce plant blindness and inspire future generations of paleobiologists to study extinct plants and animals.

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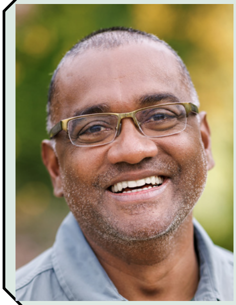
The Fulbright U.S. Scholar Program: Insights from a Fulbright U.S. Scholar Alumni Ambassador

In 2015, I finally decided to take a closer look at The Fulbright Program (https://www.fulbrightprogram.org/). Although I had known about the Program for decades, I never considered it as an option; I perceived it to be "too prestigious" and "out of reach," especially for someone working at a predominantly teaching-focused university. However, two colleagues from College of the Atlantic (COA), a small liberal arts college on the coast of Maine where I taught botany for 10 years, had received Fulbright U.S. Scholar Awards a year or two before, prompting me to explore the opportunity for an upcoming sabbatical. Now, nine years after I mustered up the courage to take on a Fulbright U.S. Scholar application, I have received two Fulbright U.S. Scholar Awards (for visits to Sri Lanka and South Africa), two Fulbright Regional Travel Program Grants (for visits to India and Madagascar), and a Fulbright Specialist Program Grant (for a visit to South Africa). Most recently, I have been appointed as a Fulbright U.S. Scholar Alumni Ambassador to promote among botanists and other professionals across the United States (and beyond) the life-changing opportunities I have had, thanks to the Fulbright Program.



By Nishanta Rajakaruna

Professor of Plant Biology, California Polytechnic State University, San Luis Obispo, CA 93407

Applying for a Fulbright U.S. Scholar Award is one of the most exciting and rewarding challenges I have taken on in my professional life, leading to eight productive years of ongoing, collaborative botanical research and teaching opportunities abroad. The Fulbright Program has helped me to build an extensive network of collaborators across South Asia and southern Africa, to visit botanical hotspots I would never have imagined possible, to view *Welwitschia mirabilis* (a species I have wanted to see since my first undergraduate botany class; Figure 1) in the Namib Desert, to work with diverse students from personal backgrounds and education systems that are very different from what I am used to, and to make lasting and rewarding friendships that have enriched my life immeasurably. In addition, students at my home institutions, COA (first Fulbright) and California Polytechnic State University (second Fulbright), as well as my U.S.-based collaborators, have also benefitted from my Fulbright travels by participating in my research abroad, by collaborating with my host country colleagues and their students, by co-authoring resulting publications and conference presentations, by visiting to give seminars at my host institutions, and by expanding their professional networks along the way. For botanists, the Fulbright Program offers

Figure 1. *Celebrating* Welwitschia mirabilis subsp. namibiana *during a visit to the Namib Desert.*

an array of opportunities to teach and carry out research at universities and botanical institutions globally, including world-class herbaria, botanical gardens, and arboreta. If you have a sabbatical coming up or have just finished your doctoral work and want to conduct postdoctoral research abroad, consider applying for a Fulbright U.S. Scholar Award (https://fulbrightscholars.org/us-scholar-awards). A Fulbright can offer an opportunity for cultural immersion with long-lasting personal and professional benefits.

WHAT IS THE FULBRIGHT SCHOLAR PROGRAM?

The Fulbright Scholar program is administered by the Institute of International Education (IIE) in collaboration with the U.S. Department of State's Bureau of Educational and Cultural Affairs. The Fulbright Scholar Program offers more than 1700 fellowships for academics, educators, and professionals each year in over 160 countries, enabling 800 U.S. Scholars to go abroad and 900 Visiting Scholars to come to the United States. The Fulbright U.S. Scholar Program is for academics (including postdoctoral fellows), educators (from community colleges and teaching- or research-focused universities), and other professionals who are U.S. citizens, offering 3- to 10-month awards to teach, conduct research, or do a combination of teaching and research abroad. Applicants should have a Ph.D. (or terminal degree for the discipline) and can include recent Ph.D. recipients, early-late career faculty, or even retirees. You can also apply for more than one Fulbright in your career, as long as you have waited for two years after the date of completion of the previous grant. However, during each cycle, you can only submit one application. For non-U.S. citizens, the Fulbright Scholar Program offers several opportunities to engage with U.S.-based academics and other professionals, including the Visiting Scholar Program, Scholar-in-Residence Program, Enrichment Program, and Outreach Lecturing Fund. Details on each of these opportunities can be found on The Fulbright Scholar Program website (https://fulbrightscholars.org/non-us-scholars). One important fact to remember is that Fulbright awards only cover a personal stipend, including a monthly allowance (based on host country and type of Fulbright Award: Teaching, Research, Teaching and Research) as well as funds for travel/relocation and living/housing expenses; major funding for research has to be secured through internal (home or host institution) or external (grants through private, state, federal, or international) sources. Research-focused grants offer a modest book and research allowance, but it may not be adequate to carry out extensive in-country research. During my two Fulbright U.S. Scholar Awards, I, along with my host and other collaborators, secured funding through sources such as the National Geographic Society, Explorers Club, as well as host country institutional and federal sources, to carry out the research proposed for my Fulbright awards. The key is to start the application process early and work closely with your host to identify potential sources to secure the necessary funding, especially if you are planning a project that requires considerable support. If you plan ahead, it can be done.

MY BACKGROUND

I was born and raised in Sri Lanka and I came to the United States in 1990, at the height of Sri Lanka's civil war, to pursue my undergraduate education in Human Ecology (emphasis Botany) at College of the Atlantic. Although I had gained admission to the Faculty of Science, University of Peradeniya, Sri Lanka, to pursue my studies in biological sciences, with the goal of specializing in botany, it was not meant to be. The plan to return to Sri Lanka after my undergraduate degree never materialized either and, after 10 more years of graduate and postdoctoral work in North America, I got my first faculty position at my alma mater, College of the Atlantic, where I taught botany for 10 years. Since then, I have taught botany at two other predominantly teaching-focused universities: San José State University (2 years) and California Polytechnic State University (Cal Poly), San Luis Obispo (7 years +). I am a geoecologist broadly interested in how lithology and landforms shape diversity, both at the species and community levels. My research focuses on the ecology, evolution, and conservation of plants and lichens of harsh substrates, particularly serpentine soils. All my Fulbright awards have involved international geoecological collaborations, focusing on the ecology of plants, lichens, and biocrusts of serpentine and other harsh substrates as well as their conservation and the restoration of their often-degraded habitats. Fulbright awards have helped extend my research from North America to South Asia and southern Africa and set up long-term studies that continue to provide opportunities for my hosts and their students, as well as my U.S.-based students and collaborators.

MY FULBRIGHT JOURNEY

I applied for my first Fulbright U.S. Scholar Award to return to my motherland, Sri Lanka, to carry out research in geoecology at the National Institute of Fundamental Studies, in collaboration with a plant scientist working on (among other things) plants of serpentine soils of Sri Lanka. With National Geographic Society funding that a collaborator in Australia and I received, and funding from the host institution, we carried out descriptive and experimental work on serpentine soil-plant-lichen associations for nine months. I also visited all the major universities on the island, including the university I gained admission to in 1989 (yet never attended a single lecture), several high schools (including my own), and leading botanical gardens and research institutions to present seminars, discuss potential research collaborations, meet with botanists and their students, and offer my guidance to anyone interested in exploring opportunities for higher education or academic work in the United States. Most importantly, my nine months in Sri Lanka helped me reconnect with family, culture, landscapes, and biota I grew up with and share my life and work in North America with those I knew since my childhood as well as new friends and colleagues I made during the Fulbright Award. While I was in Sri Lanka, I applied for and received a Fulbright Regional Travel Program grant to visit the Department of Botany, Aligarh Muslim University, India. That 14-day visit, my first to neighboring India, was packed with seminars and meetings, leading to a mutually beneficial relationship that is still ongoing. My second Fulbright, five years after my first, was to the School of Biological Sciences, North-West University (NWU), Potchefstroom, South Africa. This time around, I decided to apply for a Teaching and Research Award. My host, who I first met as a fellow graduate student at an international conference 23 years ago, and I designed a new class titled Geoecology, which we co-taught during my first semester at NWU. The second semester, we carried out field research we had planned together, and I visited eight universities and botanical research institutes across South Africa to give research seminars and meet with botany students and faculty (Figure 2). These visits were a highlight of my Fulbright experience, giving me the opportunity to network with botanists from across the country and serve as a mentor for numerous South African students. I then applied for a Fulbright Regional Travel Program Grant, this time to visit the Missouri Botanical Garden

Figure 2. *With students after a guest lecture on geobotany at North-West University, Potchefstroom, South Africa.*

of Madagascar. Visiting Madagascar had been a life-long dream and I enjoyed every minute of my 14-day visit. I gave seminars (Figure 3), set up a research agenda with my hosts for investigating soil-plant-lichen relations of the unexplored serpentine outcrops of the island, met with many young botanists eager to make their mark, and helped write grants to fund geoecological research in Madagascar. The visit also gave me insights and field experiences that I have incorporated into my teaching of Biogeography, an upper division course I continue to teach at Cal Poly. I was also fortunate enough to receive a Fulbright Specialist Program Grant to South Africa just this past summer. This Program, administered by the World Learning Organization, is another wonderful opportunity for U.S. professionals, including academics, to engage in short-term projects (up to six weeks) with hosts from around the world. Please check the Fulbright Specialist Program website (https://fulbrightspecialist.worldlearning.org/) for the application process. Since my awards, I have found many ways to engage with The Fulbright Program. I serve on the Fulbright U.S. Student Program selection committee at Cal Poly, have assisted in the discipline peer review committee for the U.S. Fulbright Scholar Program on three occasions, and, currently as a Fulbright U.S. Scholar Alumni Ambassador, I help promote Fulbright opportunities among U.S. academics and other professionals interested in educational and cultural exchange. I have thoroughly enjoyed

Figure 3. *After a presentation to botany students at the University of Antananarivo, Madagascar.*

the many opportunities I have had to promote the Fulbright Program, to share my insights with those applying for Fulbright awards, support their passion and excitement for travel and global exchange, and vicariously experience their joy once they have embarked on their own Fulbright journeys.

THE FULBRIGHT U.S. SCHOLAR APPLICATION

The application deadline is mid-September and the new cycle of Fulbright awards (for the following academic year) goes online in February. The application process can be lengthy, so planning ahead can help promote success. The application consists of short answer questions on why you chose a particular host country, how the proposed work fits your career trajectory, your cultural adaptability and ambassadorship and, if you are applying for an award with a teaching component, how you plan to adapt to a new teaching environment. Each answer has a character limit; therefore, it can take time to fine-tune your answers. In addition, there is a 3-page (for teaching only awards and research only awards) to 5-page (for teaching + research awards) Project Statement requirement to provide your rationale for the proposed work in the host country, your approach, the timeline, as well as describing the benefits to you, your home institution, and your host and country. There are two required Letters of Recommendation as well as a Letter of Invitation from the host or host institution (for most awards). If you have an ongoing international collaboration, want to establish a new collaboration with someone you have met along the way, or want to branch out to a new area of research with an expert who is based internationally, a Fulbright U.S. Scholar Award can pave the way. To obtain a letter of invitation (if your application requires one), you can reach out to a prospective host with your idea for collaboration and see if they are interested in hosting you as a Fulbright U.S. Scholar. The answer, almost always, will be an enthusiastic yes!

You can get plenty of guidance as you work through your application, from attending Fulbright Office Hours and online webinars, as well as reaching out to an Alumni Ambassador like myself. The Fulbright Scholar Directory (https://fulbrightscholars.org/fulbright-scholar-directory) is a valuable resource to find alumni by Fulbright program, discipline, host country/institution, and scholar name. "Fulbrighters" enjoy helping prospective applicants, so never hesitate to reach out to alumni who may have spent their fellowship at an institution you may also be interested in visiting. Their insights on the host country, host institution, and available opportunities for cultural and educational outreach can be extremely useful in your application preparation. This year, I have worked closely with half a dozen applicants, answering questions about the application process and reviewing project statements and short essays to provide advice and insights. Personally, I found the application process to be highly rewarding, giving me the opportunity to reflect on my research, including broader societal and global impacts of the work I do, and even shape my professional aspirations for the future. One thing to note is that your Project Statement is not a grant proposal to be submitted to a federal agency, such as the National Science Foundation. The Fulbright Program values cultural exchange as much as discipline-related rigor. Strong statements balance discipline-related content with descriptions of desire for cultural immersion and exchange. Describe opportunities you have for mentoring students; giving guest lectures, seminars, and workshops; engaging with others at the host institution and outreach efforts, as well as your commitment to represent the United States as a cultural ambassador and your genuine interest to learn about the host country, its people, and their ways. I believe it is critical to prepare your project statement in collaboration with your host or host institution so that the work proposed, whether it is research or teaching or a combination of the two, reflects host institution interests and needs as well as those of yours.

FULBRIGHT OPPORTUNITIES FOR STUDENTS

For students, please visit the Fulbright U.S. Student Program (https://us.fulbrightonline.org) to explore eligibility and program requirements for English Teaching Assistant (post-undergraduate degree) and Open Study/Research Awards (undergraduate degree holders or current graduate students) and reach out to your home institution's Fulbright Office or Fulbright Scholar Liaison for institution-level assistance and application deadlines for institutional review. You can also contact a Fulbright U.S. Student Alumni Ambassador for insights and guidance on the application process. Similar to U.S. Scholars, students too have access to a Fulbright Grantee Directory (https://us.fulbrightonline.org/alumni/grantee-directory) to find alumni they can reach out to for guidance. Fulbright U.S. Student Program Awards, especially the English Teaching Assistant Awards, are ideal for those looking for an enriching cultural and educational experience during a gap year or for post-undergraduate studies. Securing a Fulbright Award will make you a highly competitive candidate for graduate study, medical or other professional programs, and employment (locally or, especially, internationally).

FINAL THOUGHTS

Personally, The Fulbright Program has been life changing. Having moved from one country to another since my early childhood, I have always appreciated seeing the world through other lenses. For those who love to travel, learn about the world through cultural immersion, and work collaboratively with persons from different personal and academic backgrounds, there is no better opportunity than that provided by The Fulbright Program. Fulbright travels have given me opportunities to experience a better work-life balance and explore new hobbies that I have come to thoroughly enjoy. During my Fulbright U.S. Scholar Award to South Africa, I fell in love with birding and wildlife photography (Figure 4), giving me a lifetime of exploring to do. Professionally, I have taken on new areas of research within geoecology and my network has also grown significantly, benefiting not just me, but my students and collaborators as well. If I could, I would live my life moving from one Fulbright destination to another, learning about the world we call home, through interactions with plants and people from distant lands. If you decide to explore the Fulbright U.S. Scholar Program for your upcoming sabbatical or your postdoctoral work, please reach out to me at nrajakar@calpoly.edu. I will be happy to help you start your Fulbright journey so you too can extend your botanical research and teaching interests beyond the United States.

Figure 4. *While photographing spring wildflowers of Namaqualand, South Africa, I witnessed a pair of Blue Cranes, South Africa's National Bird. This photograph of the cranes on a carpet of native wildflowers has instilled in me a life-long passion for birding and wildlife photography.*

Twelve Pounds of Duct Tape and No Manual: Shifting Mindsets Around Disability in Botany

At Toolik Field Station (North Slope, AK), things only work because there are 12 pounds of duct tape on them. I stood on a rickety old boardwalk watching a machine we lovingly called "The Tram" beep its way across the tundra, praying that this wasn't the day the bungee cords holding it together snapped. The Tram measured relative NDVI (relative greenness), reflectance, temperature, and canopy cover on the North Slope of Alaska with multiple cameras unceremoniously strapped onto a platform that hovered on cables 3 feet above the tundra. I was hired to help run two of these machines in the Arctic, and when our team managed to get both to run across and back without missing an on-switch or something coming unplugged, we deemed the day a "Big Success."

Watching this machine beep through the tundra for multiple hours a day left me a lot of time to contemplate the similarities between the robot and my own body's wiring issues. At 2 years old, I was diagnosed with a brain condition that can best be described as "my brain is too big for my head," which has caused significant pain and nerve issues throughout my life. I have had corrective brain surgery twice but still struggle to get my nerves to properly communicate with the rest of my body, much like the fraying wires in The Tram. I stood on the boardwalk and asked myself, *if The Tram and I both had these "wiring" issues, how was it that we ended up in the Arctic with little other than duct tape to help?*

By Caroline Bose

PhD student,
University of Wyoming

Email: cbrose1@uwyo.edu

I find a certain beauty in things that achieve goals even in a round-about and inefficient way. Looking into the control box of The Tram, you'll likely find a 15-year-old computer, an old car battery, and an assortment of cables labelled with faded, barely legible handwriting. Despite this, with enough encouragement, extra batteries, restarting of the software, and prayers to any and every entity possible, it almost always completes the job it was designed to do. I've recognized that with a machine like The Tram, or in a body like mine, it's the time, care, and respect for its abilities that will allow for the most productive outcome. Rainy days often mean The Tram cannot run, which can easily frustrate those of us whose jobs rely on it beeping across the tundra. However, a simple step back would show that these rainy days allow for the scientists to download and begin analyzing data and, more importantly, a period of rest for software and human alike. This shift in mindset has brought so much peace to my life, because I have started appreciating days when my body says, "Please not today," rather than resenting the lack of productivity.

Recognizing that "productivity" looks different for everyone has been one of the most important things I have done for myself, because it helps me not compare my work ethic to that of my peers. Graduate school has found me working to dismantle my internalized ableism as I try to be prouder of myself and all that I am able to accomplish despite fighting my constant headaches and nerve pain. I have been incredibly lucky throughout my scientific career to have understanding and accommodating advisors, and for that, I will always be grateful. I recognize not everyone is as fortunate or might not feel as comfortable sharing their disabilities or struggles with peers or advisors, and it's often difficult to ask for help or an accommodation when they aren't aware of the situation. As someone with an invisible disability, it can both be a blessing and a curse to be able to easily hide what is going wrong in my body. It is difficult to continually have to remind people of the accommodations that I might need because it is easy for others to forget when it is not always obvious.

Within botany and academia as a whole, we need to curate a more accessible culture by recognizing that there are unseen factors that affect our colleagues' lives and adjust our expectations for "productivity" accordingly. For the last four BSA conferences, there have been mixers for disabled botanists and allies to help build community. I was lucky enough to help organize and host this year's event, and the turnout was better than I ever hoped. Our discussions of shared experiences and challenges navigating a scientific career made me feel less alone, as I imagine it did for the other attendees. We had an incredibly productive discussion about accessibility at scientific conferences and in academia, and our suggestions and comments were discussed with the BSA board shortly after. A core emphasis of many of our conversations was the importance of advisors and supervisors understanding that disabilities are explanations, not excuses. Asking for accommodations is how we set ourselves up to be as successful as possible in a system that is not built for us. As a continuation of that conversation, this September we hosted a Botany360 event as an affinity group and shared experiences, ideas, and suggestions for the future. As incredible as it is to meet up with other disabled botanists and allies, this is only the first step. After building our community within the field we must also think about our visibility in the field more broadly. Increasing visibility of disabled botanists is important for younger scientists to see to help them accept themselves.

Arguably one of the most stressful parts of field seasons are when the Principal Investigators show up and start checking to make sure everything is running as they expected. When my boss arrived at Toolik, he always had the keen ability to find every machine we had and disassemble it before leaving the lab in disarray and going to bed. It was usually helpful, considering he was the only one of us who could fix many of the major mechanical problems we had with The Tram, but it always left us a bit nervous that he might not know how to put it back together, especially when there were never any instruction manuals in sight. Seeing pieces of the machines strewn across the table allowed us to identify the inner workings that we were otherwise too afraid to explore without a reference image.

Seeing the parts of The Tram laid out was one of the most eye-opening experiences I can remember, especially since Toolik was where I did most of my self-reflecting about my illness. One afternoon on a day off, my co-workers and I were finishing a hike down the side of a mountain when I was hit with multiple difficult realizations at once. First, and most pressing, I could not feel my legs—if my balance shifted in the wrong direction, I was headed down the slope with no ability to stop myself. The other, more shocking realization was the connection I made between being chronically ill and the fact that I was going to have this problem for the rest of my life. It sounds like a simple connection, but my first surgery happened when I was only 2 years old. I spent my childhood considering my illness as something I "used to have," and I always assumed I would get back to

I could look up to during my early career. I have spent a significant amount of time trying to ignore the realities of my chronic illness, instead trying to convince the world (and myself) I was no different than my peers. Only in recent years have I found strength in recognizing that my illness is not something that should make me ashamed of myself. Despite there never being a true instruction manual on how to navigate life as a scientist, representation is one of the most important things for young people no matter the field or topic. To help with this, we are planning to host a symposium at a future BSA conference highlighting the research done by disabled scientists at all career stages. We are here and proud, and we hope that a symposium such as this will allow a wider audience to think about how they can create a more accessible environment. Shifting our mindsets toward creating a more inclusive future starts with productive conversations from all sides, but cannot entirely rely on those of us who are disabled. Working toward a more accessible and inclusive field requires a collaborative effort in which able-bodied allies are as loud as we are in asking for change.

The reference manual for navigating a scientific career is not meant to be written by a single author—it should be a collage of stories and experiences from every community. I hope that this submission of mine into the chapter of disabled scientists will help someone along the way feel a little better about celebrating their identity. Whether you are disabled, an ally, or unsure what label to give yourself: come to our mixers, contribute to the conversation, stand up for yourself and others, and send us your feedback, comments, and ideas on how to make our society more inclusive.

If you have feedback, ideas, or want to join the conversation, please email me at cbrose1@uwyo.edu or visit BSA's Accessibility webpage for the link to a suggestion form.

REPORT FROM 2024 CONGRESSIONAL VISITS DAY

Each year, the BSA Public Policy Committee awards two early-career botanists the opportunity to attend the American Institute of Biological Sciences' Congressional Visits Day. This event is hosted by the Biological and Ecological Sciences Coalition, and recipients obtain first-hand experience at the interface of science and public policy. The first day includes a half-day training session on science funding and how to effectively communicate with policymakers provided by AIBS. Participants then meet with their Congressional policymakers, during which they will advocate for federal support of scientific research. This article details the experiences of this year's recipients: ***Jenna Miladin*** *(University of Arkansas) and* ***Cael Dant*** *(Northwestern University & Chicago Botanic Garden)*

Jenna Miladin (left) and Cael Dant

Jenna Miladin's Experience

My early interest in plant evolutionary biology has led me to research various aspects of the role a changing climate has on evolutionary patterns in plants. During the completion of my Master's degree, I worked for the National Forest Service and National Park Service, which allowed me to complete various research, monitoring, and restoration projects on federally protected public lands. My experience during this time has led me to think more broadly about the application of science, and it allowed me to find parallels between my academic research and my on-the-ground conservation work. This has shaped my commitment to research that uses evolutionary biology methods to inform land management and conservation practices. This is also how my interest in public policy and the ways in which it influences how we conserve both individual species and landscapes was cultivated. Given the increasing threat species and landscapes face due to climate change, it is imperative not just to understand the adaptation of plant systems and patterns of biodiversity in the wake of these pressures, but also to translate this type of work to inform public policy.

The opportunity to attend Congressional Visits Day with the American Institute of Biological Sciences (AIBS) allowed me to expand my knowledge of how federal funding for science operates and different ways scientists can interact with policymakers to influence public policy. This experience gave me training to interact with those who make public policy and effectively communicate scientific information to individuals without a scientific background.

A crucial part of advocating for science funding in this setting was learning how to convey your message in a way that was both compelling and connected to the goals of the audience. The AIBS science communication bootcamp we attended helped us practice communication techniques as well as research who we were meeting with. This event was an opportunity to experience the importance of effective science communication in order to convey the needs of communities and the researchers advocating for them.

The AIBS bootcamp also introduced me to the other scientists in attendance with similar goals of reaching their own political audience members and communicating the scientific needs of their respective states. These scientists were incredibly diverse in their backgrounds, skills, and fields of study. It was incredibly beneficial to interact with this group; I learned about a range of different research occurring across the United States, as well as the various types of community problems that could benefit from scientific input. Additionally, we gained invaluable insight from the experts in scientific communication, journalism, and public policy. These individuals have a lot of experience conveying scientific messages to a wide breadth of audiences and prepared us for our meetings.

On Congressional Visits Day, I teamed up with a scientist from Texas where together we attended meetings with the staff of three Arkansas representatives and two Texas representatives. Our goal was to both convey the impactful research that is currently coming from our respective states that was made possible by NSF funding and emphasize the importance of our representatives' support of NSF funding. We advocated for $11.9 billion in NSF funding to reach the goals of the Chips & Science Act. The biggest challenge we faced was connecting the objectives and accomplishments of federally funded research with the goals of our representatives to address community-level problems our states face. It was important for our representatives to both understand and relate to our message.

The conversations we had with representatives and their staff was an insightful and eye-opening experience. Research coming out of Arkansas has greatly benefitted from NSF support, and it was encouraging to see how impactful these anecdotes and statistics were to the representatives. This was an opportunity to connect with our government in a way that has the potential to positively influence policy and funding.

Building on my previous work, my current research aims to understand evolutionary drivers of plant rarity and has implications for the conservation and management of these rare species. Collaboration with the IUCN Red List and NatureServe is an integral part of my dissertation, and understanding the ways in which this type of work can influence public policy is key to producing a scientific product that may make a positive influence. My experience in the communication bootcamp and on Capitol Hill gave me the tools to interact with public policy makers, and knowledge on what scientists can do to inform public policy.

CAEL DANT'S EXPERIENCE

My interest in science policy grew out of a nontraditional and interdisciplinary career path. As an undergraduate at Indiana University, I studied biology, Japanese language, and fine arts while also working in medical research and plant physiology labs and the university's herbarium. I knew I loved botany and wanted to pursue it long-term, but with my feet planted in so many fields, I struggled to envision my place in a traditional scientific research trajectory. After graduating, I transitioned out of academia and spent five years working in the public sector in Japan, first as a translator and international relations specialist for a local government and later as a program coordinator at an international education foundation. Working as a public servant and as someone whose job was quite literally to facilitate communication between parties who could not otherwise understand each other showed me what had been missing from my image of life as a plant scientist: education, meaningful connection with the public, and the opportunity to bridge communication gaps.

In 2022, I joined the Plant Biology and Conservation graduate program at Northwestern University and the Chicago Botanic Garden, where I am conducting research on carnivorous plant ecophysiology and working as an administrator for the Garden's Research Experiences for Undergraduates (REU) Program. Science policy quickly clicked for me both as an intersection point for my interests and as an opportunity to advocate for the needs of the plant science community. I was honored to receive one of two 2024 BSA Public Policy Awards, and in April of this year, I participated in the American Institute of Biological Sciences (AIBS) Communication Boot Camp and Congressional Visits Day in Washington, D.C. While I felt accustomed to interacting with policymakers and state officials from my time in local government, that work was largely apolitical and, crucially, focused on translating the perspectives of others rather than communicating my own. The training AIBS provided emphasized strategies for conveying scientific research (both our own and that of others) to non-scientists in concise and easily understood ways, as well as framing our asks in ways that aligned with the priorities of our audience. On the first day, the workshop participants—a group of students and scientific professionals from incredibly diverse academic and personal backgrounds—practiced pitching our own research to one another as we might to a policymaker in order to convey the need for research funding, followed by individual mock interviews in front of the group. We received invaluable feedback and insights from experts including lobbyists, policy researchers, active state representatives, and science communication and media professionals, and after two days of training, we spent a full day on Capitol Hill meeting with the offices of our state senators and representatives.

For the Hill visits, I was paired with one other workshop participant, and together we met with congressional staffers and, in one case, a serving senator, from our home states of Ohio and Indiana, to advocate for increased funding for scientific research at the federal level. My partner for the day was a neuroscience researcher, U.S. Army veteran, and community college professor seeking funding for scientific employment and training programs through the National Institutes of Health (NIH), whereas I was a civilian botany grad student focused on National Science Foundation (NSF) funding for plant science and undergraduate research programs. We surprised ourselves with our ability to present a cohesive and sincere pitch to our representatives despite our very different backgrounds, and we realized that by focusing our message on improving education, employment, and the competitiveness of research in our respective states, and by sharing personal stories from our own lives to supplement fact sheets and statistics, we were able to have genuinely productive conversations with the offices we visited.

I am so grateful for both the training we received and for everything I learned from my partner and fellow participants, and I hope other current and future plant biology graduate students will also seek the opportunity to attend this workshop. Inspired by my experience at this event, I have since joined the Journal of Science Policy and Governance Ambassador Program and the board of Northwestern University's Science Policy Outreach Taskforce. Science policy affects everyone and everything, from academia to ecology to environmental justice, and I hope to help amplify the voices of other researchers and advocate for the needs of the community and the ecosystem to those who have the power to effect change most. Thank you to everyone at BSA who made this experience possible!

MEMBERSHIP NEWS

BSA Virtual Symposium on Climate Change: *Plant Resilience and Conservation for a Changing Climate*

On November 14-15, 2024, BSA held a two-day virtual symposium with the theme, "***Plant Resilience and Conservation for a Changing Climate.***" Over 1100 people from across the world registered for this free event, which was open to the public, and an average of 300 people attended the event each day. Each day had a unique theme, and there were 6 featured speakers and 12 contributed talks. At the end of each day a discussion session allowed for attendees to enter breakout rooms, make connections, discuss specific questions, and report back to the main group.

To learn more about this event—including the symposium overview, topics, daily schedule, abstracts, featured speakers and their bios, and a list of the contributed speakers—see https://climatesymposium.botany.org/plant-resilience-and-conservation-for-a-changing-climate. This event was recorded and access to the recordings can also be found on the event website.

Your BSA membership dues and donations made this and other important programming possible. *Thank you!*

By Amelia Neely

BSA Membership & Communications Manager

E-mail: ANeely@botany.org

SUPPORT GRADUATE STUDENTS WITH YEAR-END DONATIONS TO THE GSRA FUND—DONATE TODAY!

Each year, BSA is proud to support graduate students with $1500 awards to advance their research through the Graduate Student Research Awards (GSRA). These awards are funded by membership dues revenue and by the generous donations of BSA members. Professional members can "opt in" to add an additional $25 GSRA support fee during their membership renewal, and all members are welcome to give to the GSRA fund during their renewal, or anytime, at https://crm.botany.org/makeadonation.

In 2024, we awarded 25 Graduate Student Research Awards, including the prestigious J.S. Karling Award. To increase this level of support for 2025, we need your help. We are currently behind last year's donation total, and every gift—no matter the size—makes a meaningful impact.

As you plan your year-end giving, please consider a donation to the GSRA fund to help us nurture the next generation of botanical scientists through these vital awards

HELP US REACH OUR GOAL OF 100 GIFT MEMBERSHIPS BY DECEMBER 31!

With the year drawing to a close, we are still working toward our goal of 100 gift memberships, but we have a long way to go and need your support to help us get as close as possible! Every $20 one-year gift membership or $50 three-year gift membership makes a real difference, helping us bring more students and colleagues from developing nations into the BSA community. Please consider giving the gift of membership today—go to https://crm.botany.org/ to get started!

You can also donate gift memberships by placing an "X" in the recipient fields. Donated gift memberships allow us to offer financial assistance to students and colleagues from developing nations who request aid throughout the year. The level of support we can provide depends directly on the number of donated gift memberships purchased, so every donation makes a meaningful impact. Please consider donating gift memberships today!

Need help? Email aneely@botany.org.

THREE-YEAR MEMBERSHIPS—STAY CONNECTED AT A DISCOUNT!

Have you considered a 3-year membership with the Botanical Society of America? A multi-year membership provides both savings and convenience: enjoy discounted rates and skip the annual renewal reminders. You can also purchase the *PSB* print copy subscription and join sections both for three years when you renew. Plus, memberships that start now will be valid through December 31, 2027!

The following memberships are available for the 3-year option:

- Professional Memberships (save $20)
- Professional Family Memberships (save $50)
- Post-Doctoral Memberships (save $15)
- Student Memberships (save $15)
- Developing Nations Memberships (save $15)

For students and post-docs, there's even more flexibility—keep your 3-year membership at your current rate even if you graduate or your position ends.

Do you know a student or a colleague from a developing nation who could benefit from extended access to BSA membership benefits and the BSA community? Three-year memberships can also be gifted or donated, providing a valuable way to keep students and international members connected and supported for a full three years.

To renew at the 3-year level or to purchase gift memberships, go to https://crm.botany.org/.

BOTANY360 UPDATES

Botany360 (https://botany.org/home/resources/botany360.html) is a series of programming that connects our botanical community during the 360 days outside of Botany Conferences. The Botany360 event calendar is a tool to highlight those events. The goal of this program is to connect the plant science community throughout the year with professional development, discussion sessions, and networking and social opportunities. To see the calendar, visit www.botany.org/calendar. If you want to coordinate a Botany360 event, email aneely@botany.org.

Recent Botany360 event recordings:

- **NFS Workshop for GRFP** (September 26, 2024) https://www.youtube.com/watch?v=uSVp279V7w0
- **Applying to Grad School 2024** (October 3, 2024) https://www.youtube.com/watch?v=la0z9yVu6n8

BSA SPOTLIGHT SERIES

The BSA Spotlight Series highlights **early-career and professional scientists** in the **BSA community** and shares both scientific goals and achievements, as well as personal interests of the botanical scientists, so you can get to know your BSA community better.

Here are the latest Spotlights:

- **Benjamin Ajayi**, Graduate Student, Florida State University, Biological Science
  https://botany.org/home/careers-jobs/careers-in-botany/bsa-spotlight-series/benjamin-ajayi.html
- **Vikas Garhwal**, Graduate Student, Indian Institute of Science Education and Research, Kolkata, India, Department of Biological Sciences
  https://botany.org/home/careers-jobs/careers-in-botany/bsa-spotlight-series/vikas-garhwal.html
- **Dennis Wm. Stevenson**, Faculty, New York Botanical Garden, Science Department
  https://botany.org/home/careers-jobs/careers-in-botany/bsa-spotlight-series/dennis-wm-stevenson.html

Would you like to nominate yourself or another BSA member to be in the Spotlight Series? Fill out this form: https://forms.gle/vivajCaCaqQrDL648.

BSA SPONSORSHIP OPPORTUNITIES

Do you know a business or organization that would benefit from being in front of over 3000 botanical scientists from over 70 countries, and over 60,000 followers on social media? The BSA Business Office has many opportunities for sponsorship including:

- Sponsored *Membership Matters* newsletter articles and footer ads
- BSA website banner ads
- Hosting Botany360 events
- Botany360 event logo advertisement during event, a slide before/after event, or time to discuss product at beginning or end of event
- Sponsored social media ads
- Advertisement space in the *Plant Science Bulletin*

Because we value our community, the above opportunities are limited with the hope of being informative without being intrusive. Sponsorships will allow BSA to fulfill our strategic plan goal of being financially responsible during this time of economic shifts.

To find out more about sponsorship opportunities, email bsa-manager@botany.org.

BSA STUDENT CHAPTERS

Did you know that there are over 20 BSA Student Chapters? These chapters provide students with valuable opportunities to network with peers at their institution through engaging activities and leadership experiences. Additionally, members can take advantage of exclusive BSA benefits, including a discounted $10 Student

Membership and heavily reduced registration fees for the Botany conferences each year! To learn more about Student Chapters, including how to start your own, go to https://botany.org/home/membership/student-chapters.html.

The following are the current BSA Student Chapters:

- Bartoo Botanical Society - Tennessee Technological University - Student Chapter
- Botanical Society of St. Cloud State University - Student Chapter
- Bucknell University - Student Chapter
- Eastern Michigan University Student Chapter
- Emory University - Student Chapter
- Idaho State University Botany Club - Pocatello - Student Chapter
- IISER Bhopal Student - Chapter
- IISER Kolkata Plants - Student Chapter
- L.H. Baileys Botany Bunch - Cornell University - Student Chapter
- Northwestern University - Student Chapter
- Oklahoma State University - Student Chapter
- Old Dominion University - Student Chapter
- Otterbein University - Student Chapter
- South Dakota State University - Student Chapter
- St. Louis Area - Student Chapter
- Texas Tech University - Student Chapter
- The Botany Club of Louisiana State University - Student Chapter
- The Gustavus Botanical Society - Student Chapter
- University of Central Florida - Student Chapter
- University of Hawai'i at Mānoa - Student Chapter
- University of South Carolina - Student Chapter
- Weber State University - Student Chapter

FROM THE *PSB* ARCHIVES

60 years ago

"The American Journal of Botany has accepted advertising for five years, but our advertising program has not really been successful. Each year approximately $1,500 is derived from this source; however, this is considerably lower than it should be. Such a program should realize about $5,000 a year.

Of course, our small circulation makes a poor impression on potential advertising customers. We do have, however, one feature which should be attractive, i. e., every reader is a purchaser or an influencer of purchases. Every member is responsible at one time or another for the ordering of research materials, books, classroom and laboratory equipment.

If every Botanical Society member, each and every time he orders or chats with a salesperson, points out the value to the company of advertising in the Journal, income derived from advertising should increase. The idea that advertising in the Journal will help the company is what we would like to get across. By no means should any kind of pressure be considered."

—Note on Advertising. PSB *10(1): 7*

50 years ago

"Hardly a month goes by that I am not asked by my departmental chairman and other administrative officers if I couldn't provide funds from my research grant to subsidize what must be considered basic university functions. Requests range from the costs of repairs of general equipment facilities to telephone and mail charges as well as contributions to graduate student support. The scenario is a common one in state universities today and represents an increasing tendency to have its staff members seek outside funds not only to pay for all costs of their research but also to pick up an increasing proportion of the tab for basic university operations.

As a faculty member in a large state institution I have become bothered by these trends in university financing. I begin to feel more like a pawn whose principal role is to attract extramural funds rather than to make basic contributions to teaching and research. Since research is one of the most important elements of my job, it is the component which weighs most heavily in my promotion and evaluation of my professional standing. Yet it is the element which receives the least support from the university. This situation generates two basic questions: (1) What is the university's responsibility to its faculty if it expects research productivity as a key element of their performance? and (2) To what extent is it justified for the university to expect faculty to generate grant funds to finance what should be covered by the university's general support budget?"
—Kaplan, Donald R. 1974. Ask Not What the University Can Do for You But What You Can Do For the University. PSB *20(4): 47*

40 years ago

"Harriet Creighton began her B.S.A. presidential address in 1957 with the paraphrased exhortation, 'Botanists of the world unite—and get going.' This must be a winning phrase because I noted that Mildred Mathias, in her address last year, drew upon that same call to arms.

Harriet allowed, in preparing for her talk by reading books and speeches, that almost everything she had planned to say about botany in 1957 had been repeated for at least 50 years and some things for over 100! With such an assessment staring at me, I can little hope to invigorate you with startling new revelations, or panaceas for successfully explaining low student enrollments to your department chairman or dean; all I can say, is that the problems and opportunities we see are the very same ones that have always been with us to a greater or lesser degree.

We are challenged today, though, as perhaps never before and we are forced, as botanists, with choices and decisions that affect the very core of our profession and our science. This kind of statement is not new, nor are the lamentations of the botanical doomsayers. We've heard them before. On the first page of the first issue of Plant Science Bulletin in 1955, almost three decades ago, there is the statement, 'On the whole, botany has not kept pace with the expansion of the other sciences and in some cases there has been a decline if not an elimination of botany from the curriculum.' More than one of you has heard a similar statement within the past months, and perhaps, even more than once. But, we are still here, still concerned with our future, still battling—I hope—to keep our profession and science above water. Yet, the ocean seems ever deeper and the undertow ever stronger dragging at us. The fact is, as departments, there are fewer of us than there were in 1955. Recent news has it that since 1978, seven botany departments have gone under—submerged into some form of biological science unit. How to stem the tide?" *
—Stern, William L. Botany in a Changeable World 1984. PSB *30(5): 32-35.*

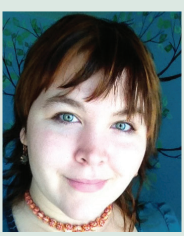
**Editor's note: This essay is a stirring call to arms with practical suggestions for promoting Botany as an academic discipline that are still applicable today. I strongly encourage you to read it in its entirety in the PSB archives.*

SCIENCE EDUCATION

Student Perceptions of Scientists: Preliminary Results from PlantingScience F2 Research Project

The PlantingScience team presented some early results of our F2 research project at the Society for the Advancement of Biology Education Research (SABER) Midwest conference in early October. This presentation focused on one of several research questions: How does online mentoring of student-led investigations impact students' views of scientists?

One goal of the PlantingScience program is to promote more expansive, less stereotypical views of scientists. Students often have limiting, stereotypical views of scientists. Although many stereotypes students have about scientists are positive (brilliant, totally devoted to work), even these positive stereotypes can be demoralizing if a student doesn't identify with a stereotyped characteristic (Lockwood and Kunda, 1997; Manke and Cohen, 2011). If students hold broader, more multidimensional views of who botanical scientists are and what they do, they may be more likely to believe that they can belong in a field like botany (Nguyen and Riegle-Crumb, 2021).



By Dr. Catrina Adams, *Education Director*

Jennifer Hartley, *Education Programs Supervisor*

There are some techniques that scientist mentor 'role models' can use to help motivate students and to counter limiting stereotypes. Establishing a connection with students, relating to students, encouraging the team's autonomy in designing an investigation, and recognizing when students show competence in their work are important ways to motivate students (Scogin, 2016). To counter stereotypes it's important for mentors to share details about their lives as scientists (e.g., what they do day-by-day, their scientific interests, career path, and the importance of the research they do). It's also helpful to share some of what they do outside of science (e.g., pets, family, hobbies, music or sports interests). It can be especially helpful to normalize experiencing some difficulty, uncertainty, and adversity in career pathways, and sharing stories about how those difficulties were navigated and overcome (Lockwood and Kunda, 1997). Teachers can also encourage students working with PlantingScience mentors to consider the scientists they worked with across the class—how this group of scientists were similar and different from each other, and how they compared with students' initial expectations about scientists. This type of reflection about direct experiences when done in a peer group setting can be an effective way to counter stereotypes (Palomba, 2017).

To better understand what students initially thought about scientists (before working with a scientist as part of the PlantingScience program), we asked students to share with us three words or phrases that describe the types of people who are scientists, and three words or phrases that describe the kinds of things scientists do. These prompts are adapted from an essay prompt "Perceptions of Scientists Survey" developed and used by Schinske et al. (2015, 2016). Student responses to these prompts are shared as wordclouds here. The results presented were gathered from our first cohort of 680 participating high school students from 24 different classrooms across the U.S. who took part in the Power of Sunlight module in Fall of 2023. We also asked these students how well they were acquainted with scientists before the intervention, and if there are specific scientists (real or fictional) who influenced their responses. A third word cloud shows student responses to this prompt. Almost three-fourths of the participating high-school students had never met a scientist before, and nearly one-fourth base what they know about scientists on fictional characters in the media.

To understand how mentoring with PlantingScience impacts students' counter-stereotypical attitudes about scientists, we gave 812 participating high-school students a five-item instrument developed by Nguyen and Riegle-Crumb (2021) as a pre-test before starting PlantingScience and post-test after finishing. We gave the same instrument to an additional 750 students who were learning photosynthesis and cellular respiration the way their teachers normally taught these subjects, without using PlantingScience or receiving mentoring from scientists. Comparing post-test results from treatment and control groups gave us mixed results. Treatment students expressed significantly higher agreement with

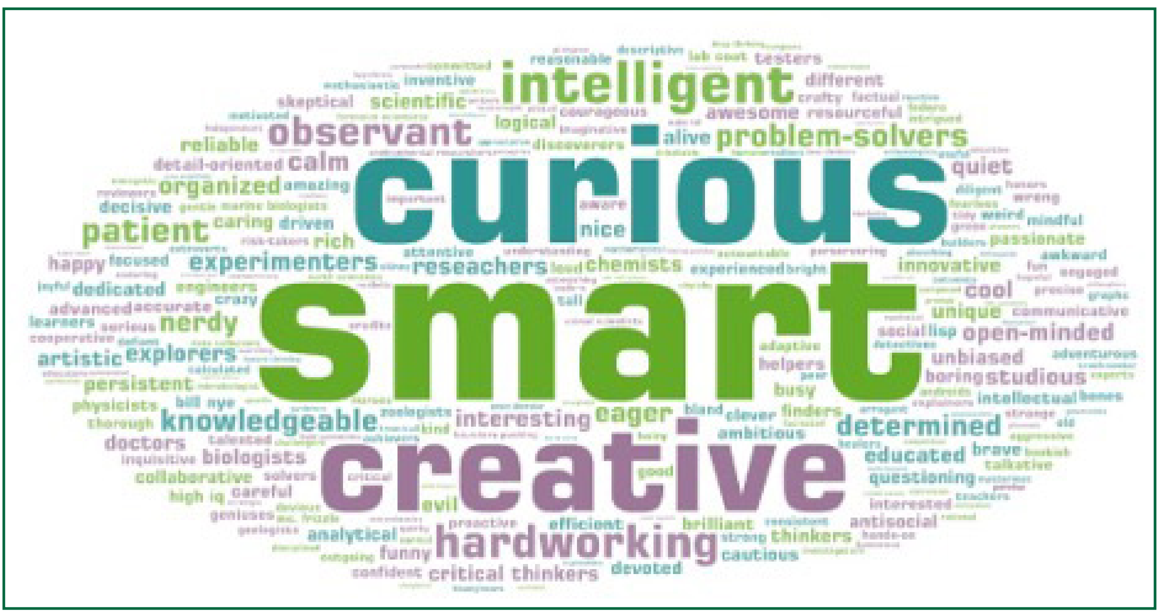


Figure 1. *U.S. high-school student (ages 14–18) responses to the prompt: "Share with us 3 words or phrases that describe the types of people who are scientists."*

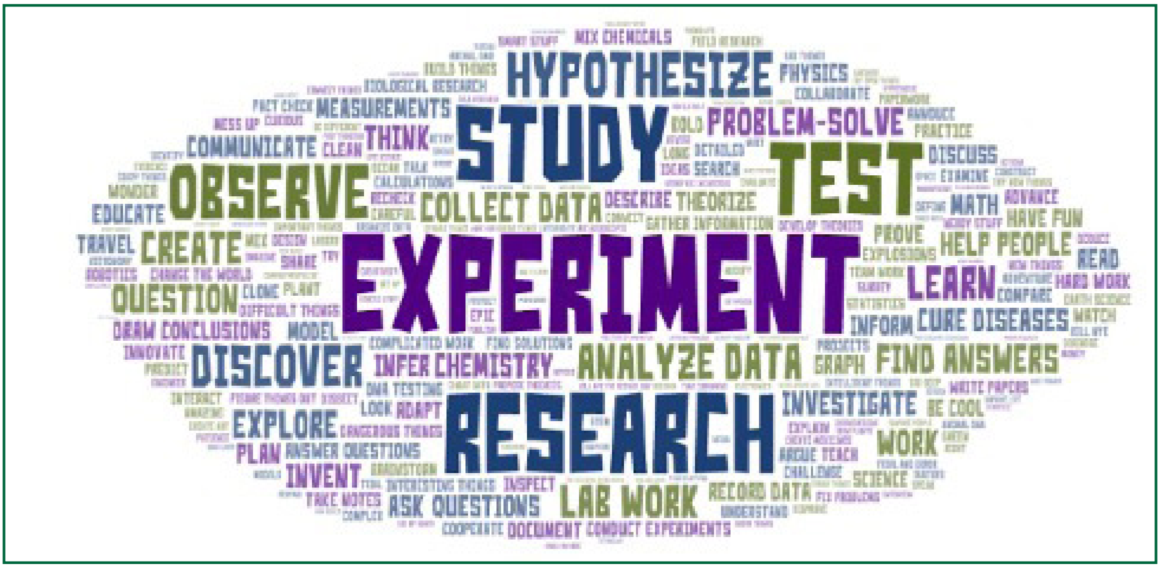


Figure 2. *U.S. high-school student (ages 14–18) responses to the prompt: "Share with us 3 words or phrases that describe the kinds of things scientists do."*

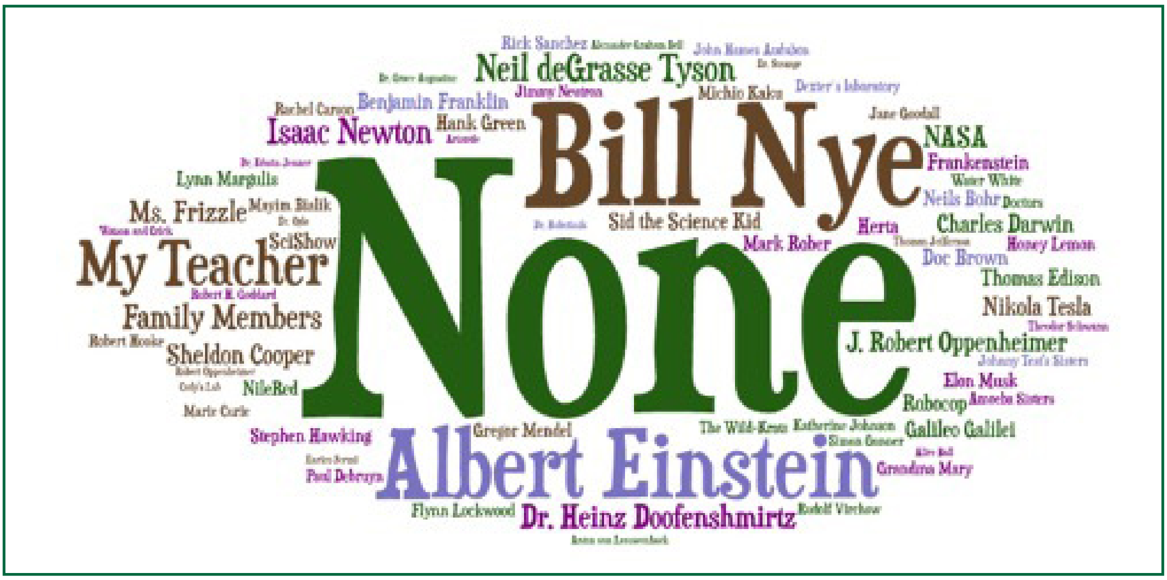


Figure 3. *U.S. high-school student (ages 14–18) responses to the prompt: "Which specific scientists (real or fictional) influenced your ideas about who scientists are and what they do?"*

the counterstereotypical ideas that scientists can work in teams or groups and that they are curious and creative people, but treatment students also expressed significantly higher agreement with the stereotype that scientists are geeks or nerds than control students.

We are also collecting data from students participating in PlantingScience at the end of the experience to ask about how they felt their projects went, and the extent to which their scientist mentors met their expectations about what scientists are like. We collected 795 responses to this survey. Over half of the students reported that communications with their mentors went well or very well, with about a quarter of students reporting that their mentor communication went poorly or not well. About half of students thought that the scientist they worked with was close to what they expected a scientist to be like. More than a quarter were neutral about how the scientist met their expectations, while less than a quarter responded that the scientists were not at all as they expected.

Free responses provide more context for these categorical responses, and we plan to analyze these data systematically in the future. A few positive quotes from students who felt the scientist mentor matched expectations include: "They were able to collaborate with us to create better science ideas"; "He behaved like a normal person but had extra information and knowledge about plants and the specific scientific categories that he specialized in"; "I thought scientists were nice, smart people who love to learn and my mentor was just that." Unfortunately, some negative preconceptions were reinforced as well: "They used a lot of big words I did not know and then they typed way too much for my brain to handle."

The students who found that their mentor surprised them often mentioned finding the scientists surprisingly relatable: "I was ready for them to have few hobbies due to how much work they have to do"; "She was cool and knew about hockey. I thought all scientists were nerds"; "I expected scientists to be more stuck up about knowing things but our mentor was very hands on and encouraged us to do our own research…" Other students were impressed by the scientists' deep interest in their research topic: "I found their passion for topics such as biology and botany intriguing." Some students who did not have satisfying conversations with their mentor mentioned disappointing surprises: "She honestly did not sound like she was very happy to work with us, she had an attitude." Results from these comments as well as an additional free response with the prompt "What advice would you give to scientist mentors?" will help us improve our mentor training materials for the program going forward.

Some insights from these preliminary data are that students mostly express positive views about scientists, even before the intervention, but that many stereotypical views about scientists are represented in responses. Most high-school students have never met a scientist, so online scientist mentors will often make a big first impression (for better or worse). Online mentoring may impact students' views of scientists, but changes may not always be toward more counter-stereotypical views. The open responses we have collected but not yet analyzed are likely to provide a lot of insight and context to the quantitative data that we collected.

Our next steps include incorporating more data from a second cohort of students and their teachers collected this fall. We're planning to look more closely at some aspects of the students' experience and how that relates to their responses to these questions. In particular, we want to know how the length and timing of their interactions with mentors, the completeness of their investigations, and how faithfully teachers implemented classroom reflections and discussions impact the students' perceptions of their scientist mentors. We will also take a closer look at selected project dialogs to see how the kinds of things scientists share about themselves, and whether students and scientists identified something they have in common, impacted the students perceptions of scientists. We're planning some exploratory analysis of classroom context and student demographics to try to determine for whom the PlantingScience intervention works best. And we are also looking at the mentor's role in meeting other program goals, like science content and practice gains and students' motivation to study plants.

Thanks so much to the BSA members and other scientists who have served as mentors and liaisons to the students and teachers participating in this research project. The project would not have been possible without volunteer support and engagement from our communities. We'll provide more updates and insights as the data analysis continues.

ACKNOWLEDGMENTS

PlantingScience F2 is a joint research project led by BSA (Catrina Adams, Jennifer Hartley) in partnership with BSCS Science Learning (Jenine Cotton-Proby, Lisa Carey, Karen Askinas, Anne Westbrook) and the University of Colorado-Colorado Springs (Joseph Taylor, Elizabeth Peterson). The project is supported by the National Science Foundation under Grant #2010556. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The project has secured BSCS Science Learning IRB approval for human subjects research and research approval from each participating school district. Student/guardian consent/assent to participate in research was collected in compliance with individual district policies.

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Palomba, R. 2017. How to undo stereotypes about scientists and science. *In* Tintori, A. and R.Palomba [eds.], Turn on the light on science, 19-49. Ubiquity Press, London, UK.

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Schinske, J., Perkins, H., Snyder, A., and Wyer, M. 2016. Scientist Spotlight Homework Assignments Shift Students' Stereotypes of Scientists and Enhance Science Identity in a Diverse Introductory Science Class. *CBE – Life Sciences Education* 15: ar47.

Scogin, S. 2016. Identifying the Factors Leading to Success: How an Innovative Science Curriculum Cultivates Student Motivation. *Journal of Science Education and Technology* 25: 375-393.

MASTER PLANT SCIENCE TEAM APPLICATIONS OPEN FOR SPRING AND FALL 2025

The MPST is a unique opportunity for early career scientists to engage even more deeply with the PlantingScience program by providing needed support to teachers! MPST members serve as a liaison between teachers and mentors and moderators of student project conversations with their mentor. With responsibilities ranging from assisting teachers with class team setup to nominating standout student projects, your contributions will make a real difference.

Plus, as a thank-you for your dedication, MPST members receive sponsored benefits like Society membership discounts, a PlantingScience T-shirt, and a certificate for your professional portfolio. Don't miss the chance to grow your leadership skills, connect with the plant science community, and inspire the next generation—apply today at plantingscience.org/getinvolved/joinmpst!

HUGE PLANTINGSCIENCE FALL SESSION WRAPPING UP

The PlantingScience team is wrapping up the Fall 2024 session. This has been our largest session in five years, with 30 teachers participating. Some were new additions to our F2 research initiative, some were returning from last Fall, and some were participating outside of the research. It has been a crazy, busy session, but we've seen some wonderful interactions between students and their mentors! In total we worked with 38 teachers serving 1241 students. They completed 324 projects, most of which focused on photosynthesis and cellular respiration.

Many thanks to the 150+ mentors and 30 liaisons who worked with us this session, and to all who helped spread the word for recruitment! Your help has made a real difference in many students' lives.

STATE-BY-STATE RESOURCE UPDATE: LIST OF STATES/TERRITORIES STILL NEEDED

What up-to-date flora or field guide would you recommend to an early career botanist that covers your state or region?

The BSA Education Committee continues to receive recommendations for our update of the BSA's State-by-State Botanical Resources area of the botany.org website. We are still looking for resources (especially the most up-to-date floras) from the following states:

Alaska, Arizona, California, Delaware, Idaho, Kentucky, Louisiana, Maine, Maryland, Mississippi, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Tennessee, Vermont, Virginia, West Virginia, Wyoming, American Samoa, Guam, Northern Mariana Islands, Puerto Rico, Virgin Islands.

It should take less than 5 minutes to submit your resource(s). To submit a resource, please use this link: https://forms.gle/VjpHPYM9pVKJ4dmh9

The Education Committee will compile these resources on the botany.org website. We are planning to release the new resource in time for the Botany conference this summer. Thanks to everyone who has already submitted a resource from your state or territory!

NOMINATIONS FOR 2025 BESSEY AWARD

Consider nominating an excellent BSA educator for the 2025 Charles Edwin Bessey Award. This annual award recognizes outstanding contributions made to botanical instruction. Ideal candidates are BSA members who are enthusiastic about teaching botany, are innovative in increasing student and/or public interest in botany, and teach in a way that increases the quality of botanical education. More information about the award and a list of past winners can be found on the BSA website: https://botany.org/home/awards/awards-for-established-scientists/charlesebesseyaward.html

Official nominations are accepted starting in early 2025, but students and early career members who would like help putting in a complete nomination packet can fill in on online form (due by March 1) for assistance in putting a packet together: https://forms.gle/3WTbB481vZc3UHao9

Botany 2024 Recap

It's hard to believe that the Botany conference in Grand Rapids was already six months ago! We're so grateful to all of you who took the time to complete the post-conference survey. Your feedback is invaluable and will help us make Botany 2025 even better!

One of the changes we're excited about next year is a reimagined Careers in Botany luncheon. We're aiming for deeper discussions and fewer transitions, allowing for more meaningful connections. As always, keep your eyes out for the student-led and focused workshops, and we will work on organizing a student workshop that caters to a wide range of interests.

If you have suggestions for future student-focused botany events or want to gain experience in organizing a workshop, don't hesitate to reach out to Ben (aderemibenjamin@gmail.com) or Josh (feltonjosh@icloud.com)—we'd love to hear from you!

By Josh Felton and
Benjamin Aderemi Ajayi
BSA Student Representatives

GRANT OPPORTUNITIES

As the semester wraps up, it's the perfect time to explore funding and support for your research! Ben and I have updated a comprehensive list of opportunities, organized into categories to make your search for funding even easier. See https://tinyurl.com/roundup-of-funding.

As always, BSA will share the society grant and award announcements and information through our social media channels, so be sure to follow us on Facebook (Botanical Society of America), BlueSky (@botsocamerica.bsky.social), and Instagram (@botanicalsocietyofamerica).

GRAD SCHOOL ADVICE

Grad school can be a challenging yet rewarding experience. Whether it's navigating imposter syndrome, balancing work and life, or managing the steep learning curve, there's always something we wish we had known earlier. Some tips we often hear include building a strong mentor support system, setting boundaries early with your work and colleagues, and remembering that it's okay to ask for help. One of our BSA members shared this insight:

"Grad school is a roller coaster—find people and activities that will support you through the highs and the lows!" - Nora Mitchell

If you could go back in time, what advice would you give yourself during the first few years of grad school? Maybe it's a study/reading habit that made a difference or something that helped you stay grounded during tough times. Share your wisdom with us at https://forms.gle/D9iwA1o1juCBYMyX8, and we will feature your advice in the next issue!

PAPERS TO READ FOR FUTURE LEADERS

As student representatives, we're optimistic about fostering a healthier, more inclusive academic culture in the botanical sciences. Below, we've highlighted a few papers we believe are beneficial reads for those who aspire to lead. If you have papers you'd like us to feature, please reach out to us!

Brown, N., and J. Leigh. 2020. *Ableism in Academia: Theorising experiences of disabilities and chronic illnesses in higher education*. London: UCL Press.

Cronin, M. R., S. H. Alonzo, S. K. Adamczak, D. Nevé Baker, R. S. Beltran, A. L. Borker, A. B. Favilla, et al. 2021. Anti-racist interventions to transform ecology, evolution and conservation biology departments. *Nature Ecology & Evolution* 5: 1213–1223.

Gin, L. E., N. J. Wiesenthal, I. Ferreira, I., and K. M. Cooper. 2021. PhDepression: Examining how graduate research and teaching affect depression in life sciences PhD students. *CBE—Life Sciences Education* 20(3).

Hamilton, P. R., J. A. Hulme, and E. D. Harrison. 2020. Experiences of higher education for students with chronic illnesses. *Disability & Society* 38: 21-46.

Ramírez-Castañeda, V., E. P. Westeen, J. Frederick, S. Amini, D. R. Wait, A. S. Achmadi, and R. D. Tarvin. 2022. A set of principles and practical suggestions for equitable fieldwork in biology. *Proceedings of the National Academy of Sciences* 119: e2122667119.

Tseng, M., R. W. El-Sabaawi, M. B. Kantar, J. H. Pantel, D. S. Srivastava, and J. L. Ware. 2020. Strategies and support for Black, Indigenous, and people of colour in ecology and evolutionary biology. *Nature Ecology & Evolution* 4: 1288–1290.

ART, ECOLOGY, AND THE RESILIENCE OF A MAINE ISLAND: THE MONHEGAN WILDLANDS

Bowdoin College Museum of Art, December 12, 2024 - June 1, 2025

In December, the Bowdoin College Museum of Art (BCMA), in collaboration with the Monhegan Museum of Art & History (MMA&H), will present an exhibition that looks anew at the history of Monhegan Island, Maine. Titled *Art, Ecology, and the Resilience of a Maine Island: The Monhegan Wildlands*, the exhibition will illuminate the Island's extraordinary journey of environmental transformation and resilience from the close of the most recent ice age to the contemporary period, as seen through the eyes of the artists who depict the terrain and the scientists who study Monhegan's dynamic ecology.

The exhibition will feature a wide range of artworks—from early twentieth-century paintings by modernist artists such as Rockwell Kent and Edward Hopper, to contemporary panoramic photographs made by Accra Shepp using his 4X5 view camera and woodcut prints created by Barbara Putnam—alongside historical artifacts such as bone harpoon points and other objects created by Indigenous inhabitants, documents from the Island's history, and scientific research on elements such as the human introduction, and subsequent removal, of first sheep and then deer.

Samuel Peter Rolt Triscott, In the Woods, ca. 1900, watercolor, Monhegan Museum of Art and History

The exhibition will open at BCMA on December 12, 2024, through June 1, 2025, followed by a presentation on island at the MMA&H that will begin July 1, 2025. An accompanying catalogue by the same title is available from Rizzoli Electa (https://www.rizzoliusa.com/book/9780847836727/).

Located 10 miles off the coast of Maine, Monhegan Island is just less than a square mile in size, with a year-round population of around 60 residents. Monhegan's small scale has enabled the kind of close study—by artists and scientists alike—that reveals in intimate detail the changes in the ecology of the forested landscape. Monhegan forests have been permitted to follow their own trajectory free from development thanks to the exceptional conservation-mindedness of the community. Fully three-quarters of Monhegan Island—the Wildlands—is conserved in a land trust where the prevailing stewardship ethos is to let nature take its course.

While Monhegan has long been a canvas for artists, it has been an equally enriching landscape for scientists, offering a unique opportunity to observe the mechanisms of forest succession and resilience on a small scale. The exhibition integrates the narratives of artists, ecologists, and the community, and that so effectively relates these instructive histories to the ongoing arc of environmental stewardship on Monhegan Island. Building on this experience, the exhibition concludes with invitations for visitors to reflect upon and express their own relationship to the Monhegan Wildlands and wildlands elsewhere.

IN MEMORIAM

PIETER BAAS (1944–2024)

The community of plant anatomists, especially the wood anatomists, suffered a major loss on April 29 of this year when Pieter Baas, BSA Corresponding Member, died on the day after his 80th birthday. Pieter earned his PhD from Leiden University, The Netherlands, and spent his entire career there, eventually becoming Scientific Director of the Rijksherbariium. After his retirement in 2005, he stayed active, being one of those people you could describe as "failing retirement." His scientific output was impressive; a full publication list provided by Van Welzen et al. (2024). The publications he is best known for are on ecological wood anatomy and classic wood anatomical monographs, including his own PhD on Ilex, and those prepared with his PhD students (e.g., Sapindaceae with Rene Klaassen, Rosaceae with Tony Zhang) and with visiting scholars (e.g., Cornaceae with Shuishi Noshiro, the Sophora group with T. Fuji). Flora Malesiana was a major project at the Rijksherbarium during Pieter's tenure as director and in addition to associated administrative duties, he wrote synopses of the anatomy of the families treated therein.

Pieter had contacts on all continents—that actually is true—because he knew people who worked in Antarctica. He had especially close ties with Kew, beginning with a year spent there under the tutelage of Professor Metcalfe. When relations improved between China and western countries, Pieter was an early invited visitor and subsequently hosted Chinese visitors, co-authoring a series of papers on the wood anatomy of Chinese trees and shrubs during the 1980s–1990s. At most conferences with sessions touching on wood anatomy, Pieter would be an invited speaker and he could be relied upon to give insightful and, when appropriate, entertaining speeches. Moreover, he also could be relied upon to always have a question or two for other speakers, so those awkward silences that sometimes occur after a presentation ends were avoided. Like many a Dutch academic, he was multilingual; he was rather proud of his English language skills and was a great fan of the daily word jumble puzzle.

If you were interested in wood anatomy, it would be on your bucket list to make a pilgrimage to Leiden to visit Pieter and use the Leiden wood collection, a collection whose well-being he was keen to preserve. Anyone who visited Leiden enjoyed Pieter's hospitality and oftentimes would be treated to a "spin" around the Dutch countryside and a quite nice meal and glass of wine afterwards. Pieter had an excellent baritone, so you might also get taken to a performance of a choir he sang in, one being the Bach Choir at the church the Dutch royal family attended in The Hague. A photo of Pieter showing then Queen Beatrix about the Rijksherbarium had a place of pride in his director's office.

For decades Pieter was the face of the International Association of Wood Anatomists (IAWA). Many submissions to the IAWA Journal were from authors who did not have English as their first language. For those manuscripts with scientific merit, he and Emma van Nieuwkoop (d. 2022) guided the authors to acceptable papers and thereby helped many establish their scientific careers. At any meeting that had an IAWA social hour, he used his baritone voice to good effect, making toasts and offering thanks to organizers. Once I heard him describing himself as shy, which was more than slightly surprising given considerable evidence to the contrary. Selling IAWA publications and welcoming new members to the association was one of his favorite activities as anyone who ever attended an IAWA meeting well knows.

One of his heroes was Rachel Carson, and he supported efforts to conserve forests and endangered tree species. This was an impetus for him to be involved in International Union of Forest Research Organizations (IUFRO) and to help organize workshops in Ghana and Kuala Lumpur for the Plant Resources of Tropical Africa (PROTA) and the Plant Resources of Tropical Asia (PROSEA), respectively. He was a major participant in World Wood Day (March 21), which celebrates and promotes the responsible use of wood and highlights wood's cultural importance.

Pieter traveled widely, and one of his travels almost resulted in us losing him sooner. He was on holiday in Sri Lanka in 2004 when the region's most powerful earthquake ever occurred, followed by a devastating tsunami. Pieter said he heard what sounded like a jet, which seemed odd as the hotel was not near an airport, then he noticed people running away from the ocean. He thought it best to join them, grabbing his wallet on the way out of his hotel room. Along with some others he made it to the top of a shed, which thankfully stayed put. Pieter's exit from the disaster zone was done in style (Pieter had style) as along his walk toward Columbo, he was picked up by a nice Indian family in a limousine and was driven to the Dutch consulate. In his last year, his travels were curtailed by the cancer that took his life.

Thank heavens for Zoom meetings becoming commonplace because they made it possible to visit with Pieter on a regular basis. Pieter, Steve Manchester, and I enjoyed weekly "Woody Wednesday" meetings to discuss fossil wood projects. Out last meeting was the week before he died. It is not nice to lose such a wonderful and supportive colleague and friend; he is much missed.

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Welzen, P.C. van, C. Lut, F. Lens, M. C. Roos, and D. J. Mabberley. 2024. In memorium Pieter Baas, 80 years old. Blumea 69: 1–10.

—Elisabeth Wheeler

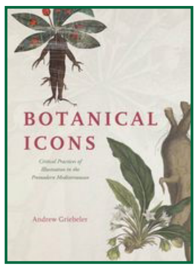
DR. ELISABETH ZINDLER-FRANK

Frau Dr. Elisabeth Zindler-Frank, a distinguished German BSA corresponding member, elected in 1997, passed away on 22 July 2024 at the age of 91. She served on the faculty of the Universität Konstanz, Konstanz, Germany for many years before retiring to her family home in Marburg/ Lahn. Her area of research expertise dealt with the physiology and anatomy of calcium oxalate crystals in the Leguminoseae. She loved the outdoors and led many field trips with her students and local community groups.

Mögest du jetzt in Frieden ruhen

BOOK REVIEWS

Botanical Icons: Critical Practices of Illustration in the Premodern Mediterranean



Andrew Griebeler
2024. ISBN: 9780226826790
US$54.99 (cloth); 334 pp.
University of Chicago Press

Andrew Griebeler's *Botanical Icons* follows the influential legacy of one book, Dioscorides' *De materia medica*, over nearly 1500 years of influence in Latin, Greek, and Arabic pharmacological traditions, as it transitioned from the original unillustrated text to illustrated versions. The "botanical icons" of the title are these images used to complement Dioscorides' text. Beautifully reproduced in this book, they represent many of the plants we treasure today in our gardens and kitchens. Readers may not know of their long history of pharmacological and medicinal use.* The text reads like a detective story as the author describes the "Critical Practices of Illustration in the Premodern Mediterranean," the subtitle of the book, by piecing together evidence from fragments and copies of illustrated Dioscorides, e.g., the Vienna Dioscorides (early 6th century), the Naples Dioscorides (late 6th/early 7th century), the Morgan Dioscorides (10th), etc. He writes, "Learning about plants from premodern illustrations means seeing plants according to how they were known and understood by people in the past" (p. 50). Out of necessity, ancient peoples accumulated "a vast botanical lore" (p. 1).

Griebeler notes in the introduction that the Mediterranean basin was a hotspot of botanical endemism with 24,000 plant species as opposed to Europe's 6000 species. Pedanius Dioscorides of Anazarbus (c. 40–90 CE), a Greek physician who traveled periodically with the Roman army, is credited with establishing the practice of pharmacology based mainly on these Mediterranean plants. Dioscorides completed the five volumes of *De materia medica* between 50 and 70 CE. He explains his methods in the preface to *De materia medica*: "I know, on the one hand, from personal observation [*autopsia*] in utmost detail most items, and on the other hand, … I have a thorough understanding of the rest from accounts [historias] on which there have been unanimous agreement and previous examination in each case by locals…." (p. 36). He criticizes those who failed to test drugs empirically and notes that he gained additional experience during travels as a soldier-physician, during which some presume he tested preparations on the ill or wounded.

At the outset Graebeler introduces Pliny the Elder's (23/24–79 CE) reservations about botanical illustration. The passage from Pliny's *Natural History*, a work of 37 volumes completed in 79 CE, which was illustrated, reads: "A picture with so many colors is truly misleading, especially in the imitation of nature, and the various hazards of copying degenerates them greatly. Moreover, it is not enough for them to be painted at single moments in their lifetime since they change their appearance with the fourfold variations of the year" (p. 9). His criticisms have merit today because field guides suffer from these problems, it being too expensive and time consuming to render a plant in all developmental stages and different seasons. Line drawings, with arrows pointing to particular features, as seen in Roger Tory Peterson and Virginia McKenny's *A Field Guide to Wildflowers*, may be more helpful than photographs in identification. Graebeler frequently alludes to the "tension" between written words and images. Pliny thought that names might suffice for identification, but as botanists know, synonyms arising for a variety of reasons can lead to misidentification.

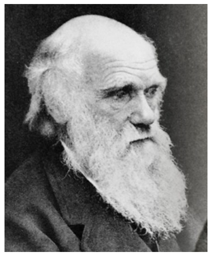
It is thought that pharmacological knowledge was first initially transmitted orally, and later written on scrolls, which participants took to symposia to exchange methods and experience, and that the extensive Greek practice of root-cutting (*rhizotomia*) inspired the first illustrated works. Fragments of a lost play by Sophocles titled *Rhizotomoi* (5th century BCE) describes Medea "'naked, shrieking, wild-eyed,' us[ing] brazen implements to gather the noxious juice of a plant called deadly carrot *[thaspia*]" (p. 17). One scholar states that by the Hellenistic period, the "murkier aspects of classical Greek rhizotomia" became more "rational" (p. 17). Griebeler writes that toxicological research went "hand in hand" with the exercise of monarchic power" (p. 21). Campaigns of conquest provided excellent opportunities for collecting botanical specimens. The discussion of the library of Mithradates VI, the Greek ruler of the Kingdom of Pontus in Anatolia (120–63 BCE), reveals that Mithradates was particularly interested in toxicology. Apparently fearing poisoning from his many enemies, he wrote books on the subject and devised antidotes, including the "mithridatium", sometimes called "the mother of all antidotes" (p. 21). Elite Roman women, like Empress Livia (died 29 CE), took responsibility for treating the ills of their household. She devised "a laxative,… and remedies for sore throat, chills and nervous tension" (p. 23). Garden room paintings from her villa at Prima Porta show a "staggering" number of plants.

Griebeler demonstrates throughout that the process of continuously correcting, updating, and illustrating the original unillustrated text through the centuries was dynamic. Illustrations were a way for the viewer to have *autopsia*, direct observational experience. Sometimes human figures were added, like that of a little man vomiting next to the illustration of a purgative. Griebeler concludes his account with the story of a Botanist Monk encountered during a botanical expedition to Mount Athos in 1937 as recounted by Arthur William Hill, director of Kew Royal Botanic Gardens at the time. Traveling on foot or by donkey, the monk searched for medicinal plants while carrying a large black bag containing four volumes of Dioscorides' *De materia medica*, which he had copied himself. Griebeler writes that the world "needs Botanist Monks and others like them to protect their preserves tirelessly. It needs both global and local views of the botanical world" (p. 232). Readers who are tempted to admire the magnificent images in *Botanical Icons* without paying close attention to the text will miss the pleasure of the prose. Most importantly, they will not have learned to see with the eyes of antiquity. I advise reading this outstanding work of scholarship from start to finish word for word.

*Pharmacological *and* medicinal *are not synonymous adjectives:* pharmacological *refers to biomedical compounds that are often delivered in preparations or drugs, whereas* medicinal *refers to a range of healthy effects conferred through soaking, poultices, etc.)*

--Elizabeth Lawson
Email: winpenny.lawson@gmail.com; www.elizabethwinpennylawson.com

Darwin Online



https://darwin-online.org.uk/EditorialIntroductions/van-Wyhe_The_Complete_Library_of_Charles_Darwin.html (including a reconstruction of Charles Darwin's personal library: https://darwin-online.org.uk/Complete_Library_of_Charles_Darwin.html)
John van Wyhe

For more than 20 years, The Complete Work of Charles Darwin Online (https://darwin-online.org.uk/) by John van Wyhe has been the most detailed, accurate, and reliable go-to source for anything pertaining to Charles Darwin. Everything is there: articles, biography, bibliography, books, diaries, letters, manuscripts, illustrations (about 100,000), photographs (starting in 1865 taken of Darwin annually or every other year except for 1875-1877), and even a collection of postage stamps (about 60 countries and regions from Albania to Yakutia) as well as playing cards.

The Darwin Online numbers are staggering: The site contains 240,000 searchable text pages, 127,800 pages of images, 118,800 scans of writings, 29 languages, 7500 PDFs, 50,000 illustrations in books, a 7,000 records Darwin bibliography and 78,000 manuscript records. In addition to being the only place in the world with all of Darwin's publications, it contains his handwritten manuscripts from over 80 institutions and collections. It also contains a very large number of items relevant to him, like 1700 reviews of his works, the entire reconstructed library aboard the Beagle and much more. Indeed, it may well be the most comprehensive scholarly website regarding any historical individual.

Altogether this is a site extraordinarily rich in content, overflowing with details and excellent in layout, management, clarity, and organization, all of which are updated often. It is easily the most informative site I have ever visited and used.

Access to the site is free and easy. No registration, no log-in name, and no password are needed. All one needs do is click and enjoy. An astonishing number of visitors have done just that: 900 million visits since 2006, according to the title page of the site.

It is possible to think that Dr. van Wyhe would rest on his laurels after such a monumental achievement. He did/does not. Recently he added to the site a complete reconstruction of Darwin's library.

Charles Darwin owned "a vast personal library" (https://darwin-online.org.uk/EditorialIntroductions/vanWyhe_The_Complete_Library_of_Charles_Darwin.html). After his death, some parts of the library were preserved. Other parts were scattered or lost. As a result, Darwin's library was often referred to as containing 1480 books because only that many were known to survive in Darwin's home (Down House) and Cambridge University. It is now clear that this was only 15% of the actual number of items in Darwin's library.

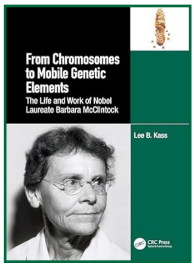
Dr. van Wyhe's reconstruction of Darwin's library required nearly 20 years. It lists 7400 titles and a total of 13,000 volumes. They are recorded in a 500-page catalog. There are over 12,000 links, which make possible nearly effortless downloading of many rare and hard-to-find books, articles, and other writings as well as paintings, photographs, and drawings. New links are being added constantly. But this is not all.

Darwin read many more writings than he owned. He "extended" the scope and size of his library by using the libraries of the Linnean, Geological and Geographical Societies, and the Atheneum Club. What he read is of interest to students of Darwin and his work because it influenced his thinking and writing. Dr. van Wyhe "extended" the reconstitution of Darwin's library by listing the libraries he used and by providing links to their catalogs. This makes the reconstitution of Darwin's library a very powerful research tool. I used it to better understand and explain a little-known letter Darwin wrote to J. D. Hooker in 1863. That is why I decided to write this review.

Dr. John van Wyhe (b. 1971) is a British historian of science at the National University of Singapore. His main interests are Charles Darwin, Alfred Russel Wallace, and evolution. I met him at the World Orchid Conference in Singapore in 2011. He gave an excellent lecture about Darwin's work with orchids.

—Joseph Arditti, Professor of Biology Emeritus, University of California, Irvine

From Chromosomes to Mobile Genetic Elements: The Life and Work of Nobel Laureate Barbara McClintock



Lee B. Kass
2024.
ISBN: 9781032365329
(hard,cover), ISBN: 9781003332527 (e-book)
US$120.00 (hard cover) US$53.59 9781003332527 (e-book)
265 pp.; CRC Press, Boca Raton, FL

In this thoroughly documented study, Kass provides a detailed biography of Barbara McClintock that not only explains her position at the forefront of cytogenetics, but also clarifies the considerable mythology that has developed around her. For instance, both Comfort (2001) and Keller (1983) note in their biographies of McClintock that her original given name was Eleanor, but the family called her Barbara. Keller leaves it at that. Comfort notes that Barbara's father officially changed her name on 18 June 1943 to obtain a passport. Kass clarifies that the notarized affidavit of name change was dated 27 May 1943, and was probably for a passport renewal. These minor discrepancies illustrate one of the strengths of Kass' research, which is evident throughout the book. Both Keller and Comfort base their works on oral interviews with McClintock and others, after the fact. Kass uses these traditional sources to search for and find documentary evidence to support, elaborate on, or correct every part of the story. This example, from Chapter 1, also fulfills one of Kass' objectives for the book: to document McClintock's family life and early schooling prior to college.

The next five chapters provide the back story of the development of genetics and breeding at Cornell University, and particularly the Emerson school of maize genetics, to which McClintock became a critical contributor. She was not the loner genius of some mythologies, but an active collaborator within a stelar group of fellow students, researchers, and mentors responsible for the Golden Age of Corn Genetics and the foundation of the Maize Genetics Cooperative. In addition to published manuscripts, reports, meeting programs, and interviews, throughout the book Kass draws on correspondence between all of the involved parties, including: Rollins Emerson, Lester Sharp, Marcus Rhoades, George Beadle, Charles Burham, Harriett Creighton, and many others to provide the historical context in which McClintock worked.

If you hear McClintock's name, you probably immediately think of transposable elements (transposons, jumping genes) for which she won the Nobel Prize. But arguably just as important was her earlier identification of the 10 chromosomes of maize and her demonstration of translocation of chromosomes through crossing over during meiosis. Although Morgan proposed the theory of crossing over for *Drosophila* chromosomes in 1911, it remained for McClintock to provide proof for the proposed mechanism. In 1929 she was able to identify the 10 chromosomes based on their relative lengths, arm ratios, and the position of dark-staining knobs. A mutation stock, provided by Burnham, had a terminal knob on chromosome 9 and resulted in 50% sterility when selfed. In 1930 McClintock showed this was associated with a segmental interchange between chromosomes 8 and 9 and the following year she and Henry H. Hill identified a linkage group of 3 genes, *C* (colored aleurone), *sh* (shrunken endosperm), and *wx* (waxy starch), also located on chromosome 9. These provided the tools for McClintock to design a set of experiments that explained the cause of sterility, allowed her to determine the sequence of the three genes on the short arm of chromosome 9 and, along with Harriett Creighton, to demonstrate where and how crossing over between chromosomes 8 and 9 occurred. Unfortunately, McClintock's concise writing was often not easy to follow. Readers often had a difficult time understanding the logic and subtleties of her arguments. Fortunately, Kass (2013) has already edited and published an electronic companion volume that includes not only copies of McClintock's original papers, but also essays and perspective papers elaborating on many of them, including the ones mentioned above. Still, I had difficulty following the logic of the original 1931 gene order and crossing over papers, even with the help of the additional resources Kass provided.

This difficulty in communicating her work was highlighted in the last two chapters describing McClintock's nomination(s) for the Nobel Prize. She was first proposed for a Nobel by Judson John van Wyk in 1976, but this was unsuccessful—as was a subsequent nomination by Adrian Srb and Robert Rabson in 1980. In 1981 she was nominated by Stanley Cohen and Howard Temin, and in 1982, Nobel Laureates Francis Crick and Joshua Lederberg separately nominated McClintock, but again were unsuccessful. Laureate Françios Jacob expressed a reservation he had with supporting the latter nomination: "It would be difficult to explain McClintock's work to the Swedish surgeons who vote for the prize" (p. 229). The following year Ira Herskowitz and Bruce Alberts were able to put together a successful nomination and McClintock was the sole recipient in 1983. (Perhaps a leading textbook author could better understand and summarize cutting-edge research than could Nobel Laureates?)

By 1930, the maize group at Cornell was dispersing. Beadle and Burnham were National Research Council (NRC) Fellows at Cal Tech and in 1931 McClintock joined Burnham then working with Ernst Gustaf Anderson. On the way to California, she spent the summer at Missouri, working with Lewis John Stadler on chromosomal irregularities induced by x-rays and in California continued her studies of the pairing of non-homologous chromosomes in maize. With her NRC funding ending in 1933, she applied for, and received, a Guggenheim Fellowship to study with Curt Stern in Berlin. Stern's demonstration of crossing-over in *Drosophila* was published only two months after McClintock's work in maize, but they met the previous year at the International Congress of Genetics at Cornell where both were presenters. They were excited to collaborate, but it never happened. Kass provides a detailed, documented account of the impact of Chancellor Adolph Hitler on botanical science, in relation to McClintock's research plans, during the lead-up to World War II.

After only a few months in Germany, McClintock returned to Cornell to complete her Fellowship. Emerson solicited two additional years of funding from the Rockefeller Foundation, but this was not a permanent job. However, the Foundation also funded a new Genetics Institute at the University of Missouri, and John Stadler invited her to become a member. She ultimately spent six years at Missouri, and a catalog of myths and legends has developed about her time there and the reasons she left. Kass devotes a chapter of fact checking to debunk these myths and to provide "a more complete and intriguing picture of the environment at Missouri when McClintock was employed there between 1936 and 1942." Contrary to some accounts, she was not denied tenure, she was not fired, she did not quit science, and ultimately, she did not leave academe.

Similarly, there is legend and myth about McClintock's time at the Carnegie Institution of Washington/Cold Spring Harbor (CIW/CSH). As Kass notes, McClintock's interest in transposition can be traced back to her earlier work on linking genes with chromosomes, during crossing over, with maize chromosome 9. However, the focus of research leading to the discovery of transposons began with a contribution to the Maize Genetics Cooperation News Letter during her first year as a resident investigator at CIW/CSH. Again, it involved chromosome 9, which, when broken, was frequently being lost. By the late 1940s

McClintock had identified a locus that would initiate chromosome breakage by inserting into a variety of gene loci. This culminated in a 1950 paper in *PNAS* that was largely ignored. This was followed by a more-detailed paper submitted to *Genetics* in April 1953—the same month Watson and Crick published their paper in *Nature*—but was not issued until January 1954. McClintock recalled receiving only three reprint requests. It was not because McClintock was not at a major university or a well-respected researcher. She was in constant contact and collaboration with many of her colleagues at several universities and had been elected to the National Academy of Sciences and was Past-President of the Genetics Society of America (and would receive the Merit Award [now Distinguished Fellow] of the Botanical Society in 1957). Of course, it is also clear from the text that sexual bias was present throughout her career, and that she was aware of it. In response to an invitation from Marcus Rhoades to spend some time at Illinois, she declined, mentioning that CSH "was the only place she had not had to face the 'anti-female bias' most of the time" (p. 159).

Probably a major factor in the slow acceptance of her theory was that she was conducting research outside the expectations of the developing dogma of molecular biology. She continued her research even after officially retiring (mandatory at age 65) in 1964. From 1965 through 1974, she served as the first Andrew Dickson White Professor-at-Large at Cornell while maintaining an affiliation with CIW/CSH. She spent one or two weeks each academic term presenting formal or informal lectures and seminars and meeting with faculty and students. This brings the cycle of the book back to the introduction because, as a first-year grad student, the author had her first of several opportunities to talk about her research with McClintock. "McClintock preferred visiting with students in their labs and joining us for dinners, and walks in the woods, rather than meeting with faculty. She told us that students were more receptive to new ideas, while faculty held preconceived notions" (p. 3).

The impact of this personal relationship between Kass and McClintock is apparent throughout the book and makes it much more insightful for the reader. The author draws on and expands her more than 25 years of research, and more than 30 publishing articles, relating to McClintock and her work. This is the definitive biography of McClintock and belongs on the bookshelf of every college library and every science historian.

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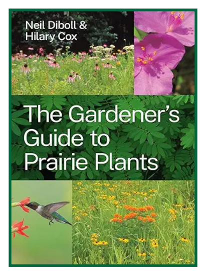
—Marshall D. Sundberg. Kansas University Affiliate and Roe R. Cross Distinguished Professor of Biology – Emeritus, Emporia State University.

The Gardener's Guide to Prairie Plants

Neil Diboll and Hilary Cox
2023. ISBN: 978-0-226-80593-1
US$35 (paperback); 644 pp.
University of Chicago Press



The Gardener's Guide to Prairie Plants contains a wealth of information useful to anyone interested in establishing, managing, or just enjoying a planted prairie, from homeowners looking to cultivate a small flower bed to those overseeing larger areas. It includes not only a field guide useful for identifying or selecting prairie plants, but also several chapters devoted to planting and caring for these plants and designing gardens.

This book begins with three chapters that provide an overview of basic plant biology and a brief introduction to the history and ecology of North American prairies. The fourth chapter discusses tips for planning and maintaining smaller prairie gardens that might be found in yards or urban plantings. These chapters are written for a general audience and are divided into short, easy-to-read sections. They include basic botanical and ecological information, as well as practical tips for things such as improving soils and converting lawns to gardens.

Chapter five is the field guide to 148 prairie species, which is divided into the sections "monocots," "dicots," and "grasses and sedges." This chapter included 75% of the Nebraska prairie species I currently grow in my own garden. Within each section, species are organized alphabetically within families. Each entry consists of a short summary description of the plant, followed by habitat information and suggested garden uses (e.g., butterfly garden, hummingbird garden). Entries also include a list of distinguishing characteristics, such as leaf texture, distinctive leaf shape, and flower position, which are written for an audience mostly unfamiliar with botanical terminology. The number of described traits and their utility for identification varies by species. Each entry also includes a paragraph on look-alike plants to draw the reader's attention to potential alternative, with page numbers for the relevant entry or entries (if included in the book), which is a very helpful feature.

The greatest strength of this book are the images included with each species entry. The authors include color photos of each plant in multiple life stages, including seedlings, plants emerging in the spring, and reproductive plants. Close-up images of leaves, flowers, and seeds are also included. The photos are clear and large enough to see detail and the images of seedlings and emerging plant are especially useful for identification when plants are not in flower. The authors state that providing these to help to gardeners who manage perennial plantings was a primary impetus for the book.

Entries include a distribution map following the standards of The Biota of North America Program's Plant Atlas; however, there was no key. I had to go to www.bonap.org to remember what the colors represented, which I was able to do only because I was familiar with this type of map. This seems like a lot to ask of an amateur botanist or gardener and lessens the utility of the guide. Including a map color key in the "How to Use this Book" chapter (Chapter One) would easily fix this.

This field guide is of use for those interested in identifying plants, but it is possibly even more useful for those looking to select plants for a garden. Each entry includes information pertinent to gardening, such as habitat type, USDA hardiness zone, soil types, root type, flower color, height, propagation techniques, aggressiveness, and deer palatability. This information is also summarized in tables in the last chapter and having it all in one reference is valuable. Of note, my edition had a printing error in which pages 231–246 were included twice. This is unfortunate, as the extra pages were inserted right in the middle of the entry for *Hibiscus moscheutos* (swamp rosmallow).

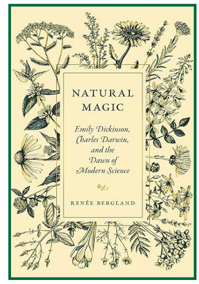
The first five chapters are likely sufficient for many, if not most, gardeners who pick up this book. The remaining chapters focus on topics relevant for more intensive prairie management. Chapter Six provides a guide for establishing a prairie meadow, including how to select and prepare a site, choose and perform different methods for seeding a prairie, and control weeds. Chapter Seven discusses best practices for prescribed burns. Chapters Eight and Nine address methods for seed and vegetative propagation, respectively. Together, these chapters comprise a comprehensive manual for establishing and managing a prairie. Techniques for tasks such as harvesting, storing, and germinating seeds, transplanting seedlings, and dividing roots are clearly described with significant detail and, often, accompanying images. Chapter Ten familiarizes the reader with common insects found in gardens, as well as the roles of small mammals, reptiles and amphibians, canines, and ungulates in native prairies. I thought that this chapter might better belong in the introductory chapters before the field guide, because it is of general interest to anyone who spends time in a prairie.

The last two chapters consist solely of tables. In Chapter Eleven, the authors provide information about seed mixes (e.g., a northern shortgrass seed mix with dry soils; northern butterfly prairie mix for medium soils). Chapter Twelve contains 30 tables useful for quickly identifying plants with a particular trait or for a particular purpose. For example, one table lists plants by height and includes information on flower color and bloom time among many other traits. Another table includes only plants that grow in dry soils, and a third table includes plants that produce blue and lavender flowers. I used these tables as I was designing a small garden to plant in the spring. It was easy to scan for potential species based on traits such as sun requirements, plant height, and bloom time. Since there are so many tables that run across multiple pages, a list in the table of contents or at the beginning of the chapter would have been extremely helpful. I spent 10 minutes searching this chapter for the table of semi-shade plants I had glanced while initially flipping through it.

This book included much more information about the act of gardening with prairie plants than I was expecting when I picked it up. I was originally interested in this book for its utility as a field guide, and I believe that the photos alone make this a welcome addition to my collection. However, the how-to chapters are a useful reference and inspired me to try my hand at more active management at home and to perhaps illustrate some of these techniques in my botany lab. I am glad to have this book on my bookshelf.

—Mackenzie Taylor, Department of Biology, Creighton University, Omaha, Nebraska, USA

Natural Magic: Emily Dickinson, Charles Darwin, and the Dawn of Modern Science



Renée Bergland
2024. ISBN: 9780691235288 (hardback), 9780691235295 (e-book)
US$32.00 (hardback), US$22.40 (e-book); 418 pp.
Princeton University Press, Princeton, NJ

In the late Middle Ages, Bergland explains, “Natural Magic” described attempts to explain unexplainable phenomena. It evolved into Natural Theology, the search for a Christian God to explain nature, and Natural Philosophy, the attempt to deduce general laws from nature. From 1500 to 1600 the terms *Natural Philosophy* and *Natural Magic* were interchangeable. During the 19th century, scientific objectivity gradually replaced more subjective methods, and the enchantment of mystery lost its appeal with the expectation that the natural world could eventually be explained mechanistically—a process termed “disenchanting the world” by sociologists. In this dual biography, Bergland compares the lives of naturalist Charles Darwin with the contemporary poet Emily Dickinson because during their lifetimes, both were affected by society’s move from “enchanted by nature” through disenchantment. Although Darwin was a generation older than Dickinson, their experiences were in near synchrony as 19th century industrialism and modernization in England occurred about a decade ahead of that in the United States.

Both Charles and Emily grew up in small country towns, the children of educated parents of some means. Darwin inherited considerable wealth from both sides of his family and Dickinson’s family was influential in the establishment of Amherst College. As children, both were frequently outdoors and both were enchanted by plants and other living things. Their school experiences, however, were complete opposites all the way through college. Darwin disliked the classroom and even in college did just enough to "get by." Dickinson loved school and was at the head of her class at Amherst Academy (which also allowed its girls to take classes at Amherst College), and Mt. Holyoke Female Seminary (later College). Whereas Darwin's formal curriculum included Latin, Greek, and mathematics, Dickinson was able to study geology, botany, chemistry, and astronomy. Ironically, these disciplines were not yet "professionalized" and were considered particularly appropriate for girls. As a result, Dickinson's formal training in science was much more complete than Darwin's.

Both Darwin and Dickinson shared a fascination with the works of Alexander von Humboldt. Darwin brought a copy of Humboldt's (1822) "Personal Narrative of Travels…" on the Beagle voyage, which he annotated heavily. Based on Humboldt's description, Darwin was anxious to visit Teneriffe, but they were unable to land because of a quarantine. Nevertheless, in his journal he describes the beauty of sunrise over the island. Dickinson's "Ah, Teneriffe – Receding Mountain –" describes an equally beautiful sunset. Both had an interest in botanizing, collecting and preserving plant specimens. Darwin's collection from the Beagle voyage was pressed quickly, and not always carefully—one specimen per sheet and sent to Henslow, at Cambridge, where they are still stored. A decade later Dickinson was carefully drying specimens and mounting them in artistic arrangements—multiple specimens per page, in a large bound book, now housed in the rare books collection of Harvard. Neither was anxious to publish their written works and both, particularly Dickinson, tended to be reclusive. Darwin's delay in publishing "The Origin of Species" is well known. Only 10 of Dickinson's poems were published in her lifetime. They shared a sense of wonder with nature and an appreciation of its interconnectedness, even as other naturalists around them became scientists, siloed in their disciplines. Science and literature were splitting into The Two Cultures later described by C. P. Snow (1969). Science was becoming professionalized, and as such, no longer appropriate for young women.

Darwin and Dickinson never met, but two of Darwin's acquaintances, Charles Lyell and Harriet Martineau, visited Amherst during Dickinson's school days and it is possible she heard their lectures. Martineau, who "dated" Darwin's brother and discussed Malthus with Darwin in London the year before he married, commented on the "40 or 50 girls" she saw attending an Amherst College Geology lecture in 1838. Three years later Lyell visited Amherst specifically to see fossil "turkey [dinosaur] tracks." It is unclear if he visited any classrooms or met any students. Dickinson likely learned of Darwin and natural selection through the Atlantic Monthly book review of Origin of Species written by Asa Gray in January, 1860.

Although Darwin and Dickinson did not know each other personally, they did share at least one personal acquaintance: Thomas Wentworth Higginson. Higginson, an essayist for the Atlantic Monthly who defended abolition and women's education, and was an early American champion of Darwin, wrote "Letter to a Young Contributor" in the April, 1862 issue of the magazine encouraging young women to become writers. Dickinson responded to him with a short note and four of her poems. He responded encouragingly and they struck up a long correspondence that continued until weeks before her death. This was conditional that he not publish her poems. He visited her for the first time in 1870 while he was in Amherst, and they talked for hours. Higginson was one of the few Americans writing prose about Darwinian natural science and in 1872 he visited Darwin at Down House. The following December he was back in Amherst where he and Emily discussed poetry and women authors she should read. One last time, in 1878, Higginson returned to Down House. He later commented on Darwin's declining health—although during the visit Darwin continued to get up early, walk the grounds, and tend to his experiments. Darwin died four years later on April 19, 1882; Dickinson died four years after that on May 15, 1886. Higginson returned to Amherst, at Dickinson's request, to read an Emily Brontë poem at her funeral.

The format of "Natural Magic" is chronological biography with alternating chapters devoted to Darwin and Dickinson. Bergland does a good job of fleshing out the personal and social influences affecting both during their lives. She places Darwin in the context of societal changes during Victorian England and Dickinson into the American changes leading up to and following the Civil War. I enjoyed these historical perspectives and the parallels between the lives of these two very different notable individuals. This would be a great book to use in a first-year experience college seminar or honors course to promote dialogue between students inclined toward the sciences and those interested in the humanities and social sciences. I'd also recommend it for college and high school faculty to foster better understanding of "the other" culture.

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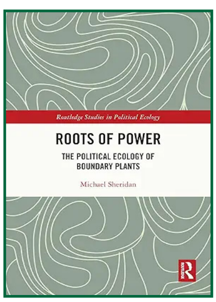
—Marshall D. Sundberg. Kansas University Affiliate and Roe R. Cross Distinguished Professor of Biology – Emeritus, Emporia State University.

Roots of Power: The Political Ecology of Boundary Plants



Michael Sheridan
2023. ISBN: 9781032411408 (hardcover) ISBN: 9781032411422 (paper) ISBN: 9781003356462 (ebook)
US$160.00 (hardcover); 275 pp.
New York, Routledge.

Boundary plants are much more than witness trees to mark geographic property boundaries, although they may certainly do that. They may also mark a sacred space; inspire social organization; assign resources; serve as a peace symbol; or be used to promote justice, fairness, and sustainability. It ties together the contemporary anthropological concept of political ecology with more traditional ethnobotany.

The author uses the first two chapters to develop the anthropological concepts of political ecology and boundary plants that form a scaffold to build five case studies illustrating these ideas. The studies are all from the tropics: two in Africa, two in the Pacific, and one in the Caribbean. They primarily involve two plant genera: *Dracaena* in Africa and the related *Cordyline* in the Pacific and Caribbean. Interestingly, *Cordyline* was first classified by Linnaeus as a *Dracaena*, and it was brought to the new world by European colonizers. With similar appearance, both monocots are easily propagated by vegetative stem cuttings, which is important for their selection as boundary plants by the indigenous cultures who use them. In Africa, the two study sites, Mt. Kilimanjaro in Tanzania and Cameroon, are on the east and west extremes of the traditional Bantu lands. In the Pacific, Papua New Guinea and the Society Islands (Tahiti) are on the west and east extremes of the Polynesian expansion. On the island of St. Vincent in the Caribbean, African slaves (familiar with *Dracaena*) were introduced to *Cordyline,* brought from Tahiti by Captain Bligh to protect breadfruit plants in transit. The case studies illustrate remarkable similarities in the roles of boundary plants in these disparate cultures while at the same time highlighting distinctive differences.

Three plants define the cultural landscape of the Chagga people on the mid-elevation zones of Mt. Kilimanjaro: bananas, coffee, and *masale* (*Dracaena frangrans*). A *masala* hedge surrounds each homestead where bananas, coffee, maize, and beans are intercropped. Here *masale* represents customary law, defining property and social relations within the family and within the neighborhood. Should a dispute arise between neighbors, the aggrieved party presents a knotted *masale* leaf to the instigator to initiate peaceful discussion to resolve the problem. The leaf expresses permanence and agency and it does so because “it never dies.” Simply plant a cutting and you’ve extended its life, indefinitely. To the Chagga, *masale* has a selfhood and individual agency, similar to Pollan’s “plants eye view” of economic plants (Pollan, 2001).

European colonialization (both German and English) promoted coffee as a cash crop grown in surveyed, rented fields in the next zone down the mountain, but it was also allowed to be produced in the family gardens. The Chagga are a patrilineal society, and the oldest son inherits most of the fields while the youngest son inherits the homestead and cares for his elderly parents. Commercialization of coffee and population growth during the 20th century has fragmented the land and driven many in the younger generations to move to urban areas and pursue upward social mobility. Nevertheless, the Chagga polycultural gardens and their *Dracaena* boundary plants persist and actually prove more resilient to climate change than the commercial farms at lower elevation managed under British Common Law.

Dracaena frangrans (*nkeng*) is also a hedge, boundary marker, and peace symbol among the several hundred small indigenous kingdoms of the anglophone Grassfields region of Cameroon, but it is not considered to have a self-hood. This rural area is also high on the slopes of a volcanic chain and has an economy based on maize, potatoes, kola nuts and honey. Sheridan’s study involves the Oku Kingdom, one of several mid-elevation kingdoms on Mt. Oku. Also a patriarchal society, it is vertically structured with a hierarchy of families below the king. In addition to the boundary functions, found among the Chagga, here the plant is also important for cleansing and healing rituals and protection from evil and witchcraft. This area of Cameroon was relatively unaffected by slavery or European colonial powers, but since independence there has been a near constant power war among French- and English-speaking factions in the country. “Compared to ineffective and corrupt state institutions, the entangled governmentality of *nkeng* is an efficient and emotionally satisfying meshwork for many people in Oku” (p. 105).

On Papua New Guinea, dozens of varieties of *Cordyline fruticose* (*tanget* plants) are used as boundary plants, depending on location and for particular uses. Agriculture involving taro and bananas independently evolved in the New Guinea highlands about 7000 years ago while *Cordyline*, a native of Southeast Asia, arrived as a “canoe plant” carried east from island to island beginning 5200 years ago. Unlike *Dracaena*, *Cordyline* has a large edible tuber, so it arrived in New Guinea already with multiple uses. Agriculture in localized areas of the island also included yams, sweet potatoes and sago palms. The different planting methods and uses of these plants contributed to the development of fiercely independent family units—but with all sharing *tanget* to mark boundaries and to promote intercultural communication. Different varieties are also used for daily wear and for ceremonial costume. Some varieties are associated with witchcraft and death whereas others boost garden fertility, control weather, or are simply used for decoration.

Three varieties of *Cordyline—Auti má ohoi uta* (dark green and most common), *Auti má ohoi raro* (light yellow-green), and *Auti má ohoi tapa* (green with yellow stripes—were carried east to the Society Islands by the Oceana mariners, along with taro, coconut, and bananas. Here *Auti má ohoi* became part of an intensely hierarchical social-ecological system with low species diversity and high species endemism. *Cordyline* (*ti*-plant) served many of the functions of boundary plants in New Guinea except rather than for small family land claims, it was for large, stratified House Societies. Unfortunately, Europeans learned early on that the leaves made good animal feed and alcohol could be made by fermenting the tubers. This, and European diseases, quickly depopulated the islands and devastated their ecology. Twentieth-century tourism has stimulated a reinvention of post-colonial *ti*-culture including firewalking (“cordyline oven”) and dancing ceremonies wearing *ti* -“grass” skirts.

Aesthetics is overtaking ethnics. Sheridan says that in these islands, Cordyline "…is now more an index of change than a marker of continuity and tradition." (p. 171).

The final case study, on the island of St. Vincent, is one of recent historical construction. European discovery decimated the native population through imported disease and warfare. European commercial enterprise mostly destroyed the native floral and fauna. The slave trade brought in subjugated West Africans, and Captain Bligh's successful second voyage to Tahiti unintentionally introduced *C. fruticose*. The Africans recognized *Cordyline* as their (*Dracaena*) boundary plant, and it became a ubiquitous boundary marker but with little role in kinship and society because slave families were broken up upon sale. *Cordyline* has been taken up as a religious symbol and is the heart of the Red Dragon resistance movement today.

"Roots of Power" is a scholarly anthropological volume that will introduce the reader to a relative new subfield of Political Ecology. For those interested in ethnobotany, it provides a useful example of the importance of plants to human culture beyond economic uses and chemical interactions on human. The boundary plants that are the focus of this study are curious in the similar interactions that developed between two morphologically similar plants in indigenous cultures half a world apart. In both cases the relatively large, attractive leaves, on a moderate-sized herbaceous "shrub," was a compelling attraction, along with their intensely green color, shiny surfaces, and flexibility in the wind or in a dance. In both cases, a key to their use was their permanence (immortality) because of their ease of vegetative propagation. And in both cases, this led to their use as living markers for their respective societies, marking boundaries, sacred spots, places of danger, and peacemaking. Finally, in both cases, these indigenous cultures were exposed to European colonizers, but the European influence had dramatically different results on the ability of the plant to retain its "power" in each of the five case studies examined.

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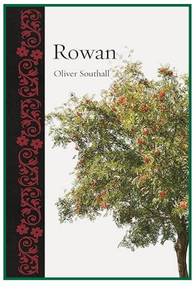
—Marshall D. Sundberg. Kansas University Affiliate and Roe R. Cross Distinguished Professor of Biology – Emeritus, Emporia State University



Rowan

Oliver Southall
2023. ISBN: 978-1789147124
US$27 (Hardcover); 248 pp.
Reaktion Books

In Rowan, Oliver Southall profiles the rowan, a small tree notable for its scarlet berries and haunting persistence, often as lone individuals, in craggy, high-elevation habitats. Many cultures have described such areas as "numinous," thresholds to other worlds, which may account for its presence in stories of myth and magic dating back for centuries. The rowan of this book is Sorbus aucuparia, the sole representative in Europe and Eurasia of a genus that includes over 90 species forming a hybrid complex in the mountainous regions of southeast Asia.* Southall, a poet living in West Sussex, UK, is the author of Borage Blue (2019), which uses borage as a focal point for plant-attentive prose and poetry. Images posted on X (@oliversouthall_) of lichens, slime molds, the green-eyed flower bee and the like indicate his ecological awareness. Although rowan is planted horticulturally, it is the wild rowan that has wielded symbolic power under many names: quickbeam, quicken tree, Witchwand, Lady of the Mountain, Delight of the Eye, and more.†

Southall states in the Introduction ("Thresholds of Nature and Culture") that "this is a book about the 'mythology' of rowan in the expanded sense" (p. 30). The unfolding of his narrative takes readers on many adventures beginning with druidical sagas and continuing with stories from Irish and Scandinavian folklore previously unknown to this reader. In medieval Ireland the exploits of a fantastical leader of "a nomad war-band" known as Fionn Mac Cumhaill (Finn McCool) took written form in the 12th century. Southall writes, "In the Finn cycle, the rowan is especially associated with adventures known as bruidhean (hostel or banquet-hall) tales: stories in which Finn and his men are lured into a parallel dimension through the fairy-tale device of some attractive residence in a remote place" (pp. 44–45). In the Bruidhean Chaorthainn ("The Hostel of the Rowans"), the banquet hall is surrounded by quicken trees and fastened "with tough quicken tree withes.'" "Ambiguous spiritual beings" populate these places, testing McCool and his men in dire ways. Another saga, "The Siege of Knocklong," contains "some amazingly over-the-top Druidical rowan magic," while "The Siege of Etain" in which a jealous wife lays a curse with "a wand of scarlet rowan" reveals the rowan's association with fire, blood, and beauty. Southall introduces Icelandic rowan lore with a description of Edda, a 13th-century text written by Snorri Sturlson, a Christian scholar living in Iceland, and Finnish rowan lore with creation stories from the Kalevala, a collection of epic poetry. In the latter, rowan twigs added to a fire had the power to predict war or peace.

In the chapter "Magic and Medicine," Southall considers the role of rowan in the lives of ordinary people in northern Europe, Ireland, Scotland, England, Wales, the Baltic, and northern Russia. Its protection and aid were sought for everyday concerns, such as fertility, of people and livestock, and malicious mischief caused by unknown beings. Southall writes that "the churning of milk into butter was marked with more supernatural associations than any other activity" (pp. 89–90). Protective practices included using rowan wood in the cowshed and tying rowan berries to the ends of cows' tails. Symbolic importance was attached to the scar, a vestige of the fallen calyx, at the base of the berry, which takes the shape of a pentacle or five-pointed star. *Sorbus* belongs to the Maloideae, and as such the "berry" is botanically a pome, or little apple.

Other chapters take us into the modern world with stories of how the rowan became symbolic in political and literary movements ("Arts of Nationhood"), and how the rowan appeared in famous paintings of the romantic period becoming the "anti-picturesque" tree ("Romantic Ecologies"). Interestingly, rowan was "unmentioned" by Shakespeare, Milton, or Pope, but figured greatly in the work of Russian writers like Boris Pasternak and the dissident Marina Tsvetaeva ("Other Russias"). The chapter "Uprootings" takes as its theme how rowans resonate in the work of writers who have witnessed "emptied spaces," particularly in Scotland. The writers include Gavin Maxwell, known for portraying life with otters in *Ring of*

Bright Water, and Kathleen Raine, his friend and poet who had mystic visions of rowans. One particularly evocative image in this chapter is Andy Goldsworthy's work of ephemeral art from 1987 titled "Rowan leaves laid around a hole/collecting the last few leaves/nearly finished/dog ran into the hole/started again/made in the shade on a windy, sunny day," (p. 188), which beautifully represents the rowan as a portal to other worlds. Autumn-tinted rowan leaves, arranged in sequential circles from dark red to orange to golden, surround a black hole.

The conclusion tells the story of one tree—a "quite ordinary" rowan called the Survivor—that was nominated for "European Tree of the Year" in 2021 by the Borders Forest Trust (BFT). Already Scotland's favorite tree of 2020, it resides in Carrifran Valley, a glen in the Southern Uplands of Scotland. Photographs show it perched "on a steep tussocky bank" against a vast, treeless landscape. The BFT purchased Carrifran and began ecological restoration, the Carrifran Wildwood project, with the John Muir Trust as partner, eventually planting 750,000 trees. Southall writes, "The Survivor rowan, then … is a threshold messenger for botanical life of all kinds…" (p. 207) including birds, who have always depended on the rowan, and other fauna like specialist aphids, rare wood ants, tree slugs, mite galls, and moths (p. 202).

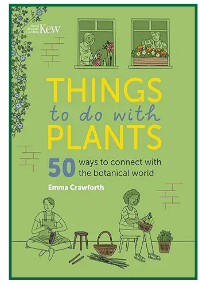
The 103 illustrations (84 in color) alongside the text equally persuade readers of the rowan's star power. This beautifully produced book is one to read closely and then reread often—and pass down as a treasured volume on the bookshelf.

* *The native sorbus of North America is* Sorbus americana, *usually called the mountain ash.* Sorbus aucuparia, *however, was introduced as an ornamental to North America and has naturalized there. Long hairs that cover the twigs, bud scales, and undersides of leaves distinguish S. aucuparia from its cousin.*

† See "Witch Tree, Quicken Tree, Delight of the Eye", www.eldrum.co.uk.

—Elizabeth Lawson
Email: winpenny.lawson@gmail.com ; website: www.elizabethwinpennylawson.com

Things to Do with Plants: 50 Ways to Connect with the Botanical World



Emma Crawford
2023. ISBN-13: 9781842467794
US $25.00 (Hardcover); 168 pp.
Kew Publishing, London, UK

As a passionate botanical artist and relatively new to the world of botany by volunteering at the Friesner Herbarium at Butler University, I was eager to review *Things to Do with Plants: 50 Ways to Connect with the Botanical World*. It was published by the Royal Botanic Gardens, Kew, one of the finest institutions for the preservation, documentation, illustration, and education about the world of plants. As stated in the Introduction, "[w]e all have a relationship with plants, members of a vast kingdom of organisms, consisting of 390,000 species at last count" (p. 6). The author's purpose is to make the plant world accessible to everyone and to demonstrate what we can do universally and individually to contribute to the continued growth and vitality of plants, even in the midst of climate change. Her focus is on using plants "in ecologically sound ways" (p. 8). The author's credentials speak to her love of horticulture and her activities as a gardening journalist.

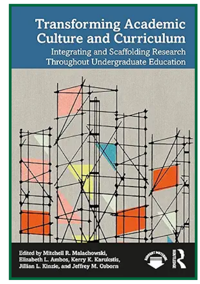
Things to Do with Plants is divided into seven sections: Save the World; Build a Community; Clothe and Comfort; Green Up a Garden; Stimulate and Soothe Mind and Body; Supply the Kitchen; and Inspire Creativity, each with a set of activities. For example, within the section Inspire Creativity are making furniture, rope, cordage, perfume and paper, pressing and preserving flowers, weaving baskets and floor mats and painting or drawing plants. Instructions are clear, accompanied by photographs or diagrams for each step. The section Build a Community includes ways to use plants to reduce noise, establish boundaries, reduce pollution, and solve crimes. Although climate change is a politically charged topic, the author avoids speculating about future scenarios, instead focusing on what we can do right now to mitigate the situation at the universal as well as individual level. Even the cover art contributes to the overall cheerful and optimistic spirit of this book.

The book provides a nice balance between history and facts about plants with activities that range from simple to complicated. Each section is in a separate color, making information easy to find. In addition to lovely photographs (often presented in circles) and drawings, there are color-coded action plans and small colored icons that correspond to each section. The book is printed on thick paper with a natural feel. A page of printed and website resources is provided, along with a two-page index.

In conclusion, *Things to Do with Plants* will be appealing to a wide variety of audiences. It includes enough information to educate people of all ages and backgrounds in the science and use of plants while providing hands-on activities that are fun, creative, and practical. Although it sounds cliché, there is "something for everyone" in this book. It will inspire and encourage readers to think about their reliance on plants and ways that they can promote, even through small changes, a better environment for all living things.

—Sara Anne Hook, Affiliate
Friesner Herbarium, Butler University, Indianapolis, Indiana
Email: shook@butler.edu

Transforming Academic Culture and Curriculum: Integrating and Scaffolding Research Throughout Undergraduate Education



Mitchell R. Malachowski, Elizabeth L. Ambos, Kerry K. Karukstis, Jillian L. Kinzie, Jeffrey M. Osborn
2024. ISBN-13: 9781032581675
Paperback, US$42.95; 282 pp.
Routledge, New York, NY, USA

From inclusive teaching practices to community-based and active learning strategies, campuses across North America are working to transform educational practices in higher education to maximize student retention, learning, experiences, graduation rates, and career success. Many educators are also now realizing the value of undergraduate research, scholarship, and creative inquiry as a pedagogical approach that builds relationships between students and mentors, helps students develop critical thinking and problem-solving skills, teaches students about research methods in a hands-on way, and prepares students for their future careers or graduate school.

Transforming Academic Culture and Curriculum is a new book on ways to transform undergraduate education through research experiences by Drs. Malachowski, Ambos, Karukstis, Kinzie, and Osborn, as well as 19 other consultants who contributed to writing the chapters. Individually and collectively, these editors and authors have remarkable qualifications, from being associate or full professors in their respective fields to past presidents or officers of the Council on Undergraduate Research (CUR). This comprehensive guidebook to enhancing undergraduate curriculum via research experiences is the result of a six-year study of educational transformations within 24 departments over 12 institutions. The book is organized into two parts and 12 total chapters. As a bonus, it includes a detailed preface, references sections at the end of each chapter, and an appendix and index at the end of the book.

Part One of the book focuses on transformation at many levels, ranging from individual student success to the overall culture of undergraduate education. The eight chapters within this first part of the book walk the reader through different levels of change, starting with Chapter One, which focuses on institutional transformation. This chapter sets up the reasoning behind and process used within the Council on Undergraduate Research Transformation Project, summarizes decades of enlightening research on undergraduate research as a high-impact pedagogical practice, and ends with how the book is structured and should be used by everyone. It seems like a choose-your-own-adventure book, with suggestions to start with "chapter x" if you are a faculty member or "chapter y" if you are an administrator. The second chapter delves into the importance of cultural transformation within departments and institutions, with sections on John Kotter's eight-stage process for organizational change that ranges from "Establishing a sense of urgency" (step 1; probably the most important step, given how slow academia works) to "Anchoring new approaches in the culture" (step 8). Each step is discussed in detail to provide background information on the step and some examples of how the step was implemented at institutions that participated in the project.

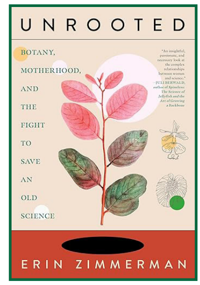
This second chapter is vital for many of the other chapters, such as Chapter Three that focuses on scaffolding development of research skills throughout a program to transform curriculum. Chapter Four focuses on disciplinary transformation in biology, chemistry, physics, psychology, and non-STEM disciplines, and forces the reader to think deeply about learning and assessment goals, course sequencing, program accreditation, and other potential roadblocks prior to navigating these transformational waters. Chapter Five is focused on using research on faculty and student success to drive evidence-based practice and curriculum change, while the sixth chapter digs into the six institutional factors that drive change, ranging from institutional mission and identity to resources and institutional dispositions (e.g., faculty workload/recognition, risk tolerance, shared governance). Chapters Seven and Eight wrap up study results with a focus on theory of change that bridges theory to practice, links it to strategic planning, discusses Kotter's strategies in the context of theories on higher education change, and, finally, summarizes many of the opportunities and challenges that arise when pursuing transformative work.

Part One concludes and transitions to Part Two, which provides a toolkit for the transformation of curriculum and culture. The remaining chapters, nine through twelve, introduce the toolkit, discuss when a department knows they are ready for change and how to make goals, establish steps for transformation, and provide direction on how to assess progress. This part includes many examples of how to use the tool from teams and consultants that used the tool in the study. Given that a diverse array of colleges and universities participated in the project, any individual from any given college or university in North America should be able to find information that is relevant to them in this toolkit. The last major component of the book includes an Appendix section with an overview of the Council on Undergraduate Research Transformation Project, including how participants were recruited and selected, the elements that accelerated systematic change and were utilized by all participants, and research methods.

Undoubtedly, the drive for institutions to use evidence-based teaching practices is essential to improve learning outcomes and faculty and student success. The CUR and other similar organizations are helping to drive the changes necessary for college and university success in this matter, but this Transformation Project and toolkit can help many colleges and universities take a much bigger leap in the right direction. The editors of the book indicate that the book is oriented toward faculty members, department chairs, undergraduate research program directors, administrators, and those who are interested in studying higher education and change theory. Although change can begin at the bottom and work its way up (as is mentioned in the book), some change must also occur from the top down. Curriculum overhauls and transformations of this magnitude will certainly require a lot of support from administrators, but also program accreditation organizations, university stakeholders, graduate employers, and many other entities. Change, especially in academia, does not occur overnight, but we can take some small steps today (i.e., establishing a sense of urgency) to create meaningful change that will improve our programs and benefit our children and grandchildren.

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

Unrooted: Botany, Motherhood, and the Fight to Save an Old Science



Erin Zimmerman
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Part way into her undergraduate career as a budding physics major, Erin Zimmerman realized she really wanted to study plants. Within a year she was working in her new undergraduate advisor's lab, learning to make botanical discoveries with a microscope at the university of Guelph. Unfortunately, this was a time when the Botany and Zoology Departments underwent a forced merger to become an animal/molecular–oriented Integrative Biology Department. She quickly realized there would likely be few academic opportunities for plant anatomists in the future, especially for a female. She asked her advisor what were her chances to succeed in this field? He candidly replied, "You just have to be the best." That's what she set out to do.

Much of the first half of the book can be viewed as an advisor's manual for how to support your (particularly female) advisees in pursuit of their passion and career. As an undergrad at Guelph, Zimmerman was the only female student in the lab, but her advisors treated her as a valuable colleague and encouraged her to pursue her interests in botanical light microscopy. Her research was published, and her advisors encouraged her to broaden her experience and contacts by pursuing a doctorate at another university. She joined a productive lab at the Institut de recherche en biologie végétale (University of Montreal/Montreal Botanical Garden) where her supportive female major professor encouraged her to design a systematics project of her own on a group of primitive legumes and to look for opportunities to build her research tool box beyond what was available at the Institut. Zimmerman uses these enriching experiences to introduce the reader to many of the tools in the modern morphologist's toolbox. Her lab focused on DNA sequencing, so the molecular tools produced a major part of her dissertation, and she describes for the reader the principles and processes involved. But she also visited Kew to learn and apply scanning electron microscopy (SEM) to examine floral development in members of her group, including Androcalymma glabrifolium, thought to be extinct in the wild. This provided her an opportunity to inform the reader about the critical role plant collections in herbaria continue to play in our studies of biodiversity and evolution. She did a "morphological bootcamp" learning descriptive taxonomy at the Chicago Botanical Garden, where her mentor, Pat Herendeen, also provided a practical example of how to be a productive botanist and raise a family at the same time. (Zimmerman was raised as an only child by a widowed father on a small farm in rural Ontario.) She spent a month on a collecting expedition in the Guyanese rainforest and uses this opportunity to introduce the reader to some historic plant collectors (Humboldt and Wallace, among others) and describe how collections must be prepared and documented in the field for both morphological and molecular studies. This also allowed her to argue for including careful sketches and illustrations of plants being collected, in addition to photo images, as a way of learning to see.

Back in Montreal, one of her lab mates, another motivated and ambitious female scientist, had her first child. She was a role model—a senior grad student in the lab who seemed to be able to "do it all." Yet, after her maternity leave (this is Canada!), she seemed to become less ambitious and competitive—and then vanished. An undercurrent through the book to this point was the leakage of talented women from science pipeline. Here was Zimmerman's first experience of this phenomenon in her own career: "I felt betrayed and self-righteous." Nevertheless, she maintained her focus and drive to finish in the next year.

That summer Zimmerman presented at the Botany 2013 meeting in New Orleans. One of the highlights for her was the workshop on botanical illustration, which reaffirmed her interest in producing accurate botanical sketches to document her research. But the real highlight came the day after the meetings while she and her boyfriend were playing tourists for a day and a half before flying home. Newly engaged, they found a pair of botanically themed wedding rings in an uptown New Orleans antique store. These were put to effect the next year, a few months after she successfully defended her dissertation. Her husband had shifted from a PhD in biochemistry to ophthalmology to avoid having to find dual academic careers, so that summer they returned to her father's farm in southern Ontario where they were married; he could work in the nearby town and she could look for a post-doc. Within a month she was pregnant. Later that summer she was invited to interview for a post-doc at a nearby government research lab. The project involved isolating and sequencing RNA gene products regulating root development. Here was another opportunity to explain some biology—how loss of function mutations is used to determine the role of genes, and how mRNA is involved in the process. Although she worked with DNA for her dissertation, RNA is more difficult to work with and she lacked background in transcriptomics. Nevertheless, her new supervisor was sure she "could pick it up" as she worked. She was offered the position, and her supervisor was also unconcerned that she would be taking maternity leave only four months after beginning.

As usual, she applied herself to learning the new techniques where timing was essential working with large numbers of plants. The day she began plating the hundreds of seeds required for her first experiment was when she realized you cannot sit comfortably for hours in front of a laminar flow hood. It turned into a late night. Finally, she was ready to start maternity leave a few days before her due date. Her supervisor delivered a bunch of new research papers she could read while off and suggested that she start writing up some of her work so far for future publication. Here was another opportunity to explain to the reader what it's like to work as a post-doc, especially a female one.

A few weeks before the end of her leave, now a mother of a young daughter, she contacted her supervisor, reminding him of her impending return and suggesting that perhaps she could slightly change her work schedule from 9–5 to 7–3 to make it easier to work out childcare. His response was a mild rebuke that leading a project was not just showing up for a certain number of hours. When the day came for her to return to work, he was not there and would be gone for a week. He forgot she was coming back. Any accommodation at work became hard to come by. "I can't remember the exact moment when I knew I was done, but by the time the days started to lengthen noticeably and I hit my one-year mark at the lab, I know I wouldn't be putting myself through another winter of this" (p. 196). Later, when she told him she would not be continuing, he was "shocked": "But you're doing a great job! You're getting good results! You can't stop *now*"—but she did.

Her transition was from professional botanist to "a botanist at large." Originally this involved freelance ghost-writing for other scientists, but then she moved into citizen science, working with the public to promote collections, herbaria, and the importance of digitizing specimens. Her last chapter highlights many of the opportunities available to engage the public in doing science.

Zimmerman's memoir seamlessly blends advocacy for the continued importance of the traditional, and often de-emphasized, fields of morphological and taxonomic research with an account of her own experiences with gender bias in the course of her botanical education and research. Together, these two stories are compelling. Zimmerman's deep appreciation for the "wonder" of botany and botanical research is made more poignant by the fact that she ultimately decides to leave the research she values because of gender issues. *Uprooted* makes an original and thought-provoking contribution to the literature about women in science and the struggles they face. This is a book I would have required in my honors biology course (M.D.S.) and women' history course (S.B.S.). It would be a valuable addition to school and university libraries.

—Marshall D. Sundberg, Kansas University Affiliate and Roe R. Cross Distinguished Professor - Emeritus, Emporia State University. and

—Sara B. Sundberg, Professor of History Emeritus, University of Central Missouri.

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Address Editorial Matters (only) to:
Mackenzie Taylor, Editor
Department of Biology
Creighton University
2500 California Plaza
Omaha, NE 68178
Phone 402-280-2157
psb@botany.org

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Congratulations & Farewell to Conference Manager, **Johanne Stogran!**

Johanne has retired after 25 years with the BSA—but stay tuned to hear more from her in the Spring 2025 issue of the *PSB*!