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FROM the EDITOR

This issue of *Plant Science Bulletin* is our second special issue highlighting the relationship between science and art. There was such a great response to the initial call for papers on this topic that it could not be constrained to only one issue. I am once again delighted to thank the team of guest editors, Patricia Chan, Rosemary Glos, Ashley Hamersma, Kasey Pham, and Nicolette Sipperly, who put this fantastic series together and the talented contributors who shared their work.

In this issue you will also find important news from the Publications Team. I will be stepping down as Editor-in-Chief of *Plant Science Bulletin* at the end of 2024 when my term ends, and we are in the middle of a search for the next editor. In the meantime, I'm excited about the features we have lined up for 2024.

Sincerely,

Mackenzie






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SPECIAL SECTION

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

Greetings,

We are thrilled to share the second issue in the special anthology, Art and the Botanical Sciences: Past, Present, and Future. The pieces in this issue continue the conversation started in our Fall 2023 issue: celebrating and re-examining the historical connections between art and botany, showcasing the varied experiences of contemporary artist-scientists, and presenting visions for future integrations of art and the botanical sciences. If you missed the first issue, we highly recommend perusing it (at https://cms.botany.org/userdata/IssueArchive/issues/originalfile/WebPSB_69_3_2023.pdf) for a vibrant selection of articles that explore the Venn diagram that is botany, creativity, and art.

In this issue, you will continue to learn about the role of botanical art across histories and traditions, fruitful contemporary collaborations between artists and botanists, innovative means of merging art and science in the classroom, and much more.

We are deeply thankful to the authors and reviewers who made this anthology possible. Special thanks to the *PSB* editorial staff for inviting us to craft these special issues, trusting us to try something new, and formatting an unprecedented number of manuscripts (!). We'd also like to thank in particular the artists who graciously allowed us to use their work for the covers of these issues. Clarissa Rodriguez created the embroidery piece used for the cover of the first issue, and Sayeh Dastgheib-Beheshti created the illustration used for the cover of this issue. This is the last issue formally dedicated to this theme, but we anticipate and encourage future submissions to the *Plant Science Bulletin* that explore these topics. If these issues have proven anything, it is that there is huge enthusiasm, interest, and fresh ideas in the sci-art space. Let's continue to maintain that energy into the future! We would especially love to hear that these issues have given people new ideas to try or new collaborators with whom to work. Lastly, if you see us around (maybe at Botany 2024 or IBC 2024?), please say hi! We love to talk all things science and art.

Until then, enjoy this issue!

The SciArt Collective
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Wunderkammer: *Boundaryless Plants*

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To the medieval mind, the 'Order of Nature' (Daston and Park, 1998) was reflected in the 'typical' form and function of natural phenomena. Anything rupturing this order—the novel, rare, capricious, 'uncanny sports,' monstrous objects brought back from distant lands—filled *Wunderkammers* (cabinets of curiosities), the precursors of herbaria and natural history collections, and evoked not only a sense of wonder, but collective terror, or at least trepidation. Collective terror of 'uncanny sports' still resides in some contemporary minds, as evidenced by response to fasciation in plants growing near the Fukushima Daiichi Nuclear facility in years following the 2011 disaster (Fessenden, 2015).

In her exhibition *Boundary Plants*, Black (2019) leveraged classically rendered botanical illustrations of three species to illuminate how Linnaeus' taxonomic system obscures the physical complexities of earth systems. The target species included fasciated *Chrysanthemum leucanthem* [sic](=*Leucanthemum vulgare* Lam.), the ox-eye daisy, to illustrate how the varied and cumulative cellular effects of the industrial age reveals the permeability of the 'clean' Linnean taxonomic boundaries. However, the levels, frequencies, and specific causes of 'natural' mutations in these species are unclear; in addition to radiation, causes include infection by pathogens, hormonal disruption, and genetic mutations (Iliev and Kitin, 2011). Further, in previously glaciated northern high latitudes, polyploidy levels and frequencies increase (Brochmann et al., 2004), masking cryptic diversity (Brochmann and Brysting, 2010) and presenting another complexity that weakens already permeable taxonomic boundaries. The European native *Leucanthemum vulgare* sensu stricto is a diploid (2n = 18) invasive in North America, and it is closely related and morphologically similar to the Eurasian tetraploid (n = 36) *L. ircutianum* Turcz. (Stutz et al., 2018). In fact, the taxonomy and associated nomenclature of *Leucanthemum* remains unstable (Roskov et al., 2018). *Leucanthemum vulgare* has been globally introduced for ornamentation as well as phytoremediation, and often escapes cultivation and establishes viable populations that alter indigenous plant communities. Ploidy levels in Alaska, where I live, have not yet been assayed, but tetraploidy in *L. vulgare* is reported from various

locales in Canada (including British Columbia; Mulligan 1958, 1968) and in Washington State. In North America, tetraploid *L. vulgare* may indeed be *L. ircutianum*, which has also been introduced to North America but is apparently less invasive (Stutz et al. 2018). Via ploidy and collateral changeable taxonomic nomenclature, morphological variability, and invasiveness, *L. vulgare* and other non-native plants (Figure 1) have become "boundaryless plants" (Black, 2019, p. 224). They breach the boundaries of classical Linnean nomenclature, which drew inspiration from Plato's ancient call to "carve nature at its joints" (Plato, 1952, p. 265e); that is, the natural world is divisible into objective, discoverable categories. Invasive plants also breach the ecological boundaries of long-established indigenous plant communities.

The SciArt exhibition *Wunderkammer: Boundaryless Plants* (International Gallery of Contemporary Art, Anchorage, Alaska, November 2023) leveraged imagery of artifacts collected during decades of floristic and plant community research on the far-flung, remote islands of the Aleutian Island Archipelago and allied island groups, such as the Shumagin Islands in southwestern Alaska. The exhibition explored issues surrounding instability in taxonomic nomenclature, levels of 'natural' mutation, community species replacement, and myriad complexities in the invasive *L. vulgare* and other plants introduced during military and ranching activities. Highlighting the entwined history between humans and these boundaryless plants in Alaska, the exhibition used contemporary botanical art to call attention to the burgeoning communities of invasive plants in these remote geographies, where the conservation focus has been trained on invasive mammals. Thus, the imagery exposes and examines what Aloi (2019) referred to as "plant blindness…our cultural inability to conceive plants beyond the prefixed cultural schemata…which simultaneously reduces them to resources or aesthetic objects" (p. *xx*). While beautiful (Figure 1), these island invasives are akin to those disturbing medieval 'sports' that breach the boundaries of known taxonomies, engendering the rupturing *unknown* that we have unwittingly invited in.

Invasive species have traversed the threshold between 'introduced' and a state wherein they expand into and a novel (to them) environment, and their ability to cross that threshold relies not only on their particular inherent biological characteristics, but also on the deliberate or passive actions of humans. By definition, invasive species are those initially introduced to novel environments by humans. Nevertheless, there is an argument that humans can (or should) be considered invasive species (Zielinski, 2011).

Figure 1. *Artist: Sandra Talbot.* But They Are So Beautiful *(*Crepis *and* Leucanthemum*). Archival ink printed on Strathmore paper, 21 × 6.5 inches. 2023. Imagery from photographs of metal collected from the site, locale photographs, and digitized field press collections of the invasive* Crepis tectorum *and* Leucanthemum vulgare *collected from the abandoned NSGA military site, Adak, Aleutian Islands, Alaska.*

Contemporary biologists largely view invasive species with trepidation, and perhaps sometimes not so differently from how the medieval mind regarded 'uncanny sports' that ruptured the Order of Nature (Figure 2). Referencing the Progressive Era—the widespread period (1890s–1920s) of social activism and political reform in the United States that addressed issues emerging from immigration, urbanization, industrialization, and political corruption—historian Philip Pauly (1996) writes that "attitudes towards foreign pests merged with ethnic prejudices: the gypsy moth and the oriental chestnut blight both took on and contributed to characteristics ascribed to their presumed human compatriots" (p. 54). Pauly further states that "…attitudes about foreign and native organisms were intimately linked… to views on 'alien' and 'native' humans" (p. 70). It is noteworthy that the common name or the gypsy moth has recently changed to the spongy moth (ESA, 2023), hopefully decoupling inherent pejorative assessments and invasiveness.

Figure 2. *Artist: Sandra Talbot.* The Pleasure of Natural Sports: Lusus naturae 3, Plot 9, View 1, ver. 2. *2023. Digital photograph of field notebook and specimen collection of fasciated ox-eye daisies, sampled from Simeonof Island, Shumagin Island group, Alaska. Top: archival ink printed on metal, 15.6 × 21.6 × 0.2 inches. Bottom: digital imagery showing a schematic of the original photograph, generated on an iPad using various applications to provide visual clarity of fasciation less readable in the photograph.*

Whether we view invasive species through aesthetic, cultural, biological, ecological, or evolutionary lenses, we judge them from within an anthropocentric world paradigm. This perpetuates a hierarchical view of non-native species that displace others: invasive species are terrible and we need to kill them, even though (depending on our deep or recent ancestry) we share certain characteristics with them. Notwithstanding controversies emerging from our own invasive-like characteristics, the history of invasive species is entangled with that of human history; by tracking the expansion of invasive species, we can track the bounding footprints of the human saga. That includes human footprints on even the remote Aleutian Islands, targets of myriad accidental and intentional introductions (Jones and Byrd, 1979; Ebbert and Byrd, 2002). Those introductions commenced about 280 years ago, following the 1742 culmination of the ill-fated Bering Expedition during which the southern coast of Alaska and the Aleutian Island Archipelago and allied island groups were 'discovered' (from western history's perspective), then described by the Expedition's naturalist Georg Wilhelm Steller.

Almost all the islands landed upon or sailed past during the Bering Expedition have endured negative ecological impacts associated with military, cattle ranching, fox farming, and other (western) human activities throughout the 19th and 20th centuries, including the introduction of non-native plants that have recently crossed that boundary between introduced to invasive. For example, following the removal of cattle between

1983 and 1985 from Simeonof Island, in the Shumagin Islands, ox-eye daisies have spread beyond the historical ranch house environs and have become an integral, even dominant, component of certain nearby plant communities. A fairly high percentage of those ox-eye daisies are fasciated, as documented using photography and digital imagery (Figure 2). The cause of the fasciation is unknown. Given a parallel to western colonial expansion into Alaska, such invasive plant species can be viewed as proxies for human expansion and community disruption, and imagery of these invasive plants can communicate these concepts.

Scientists during the European Age of Discovery were often competent to highly skilled artists, and art provided a critical means to communicate that Age's scientific discoveries. While a competent writer whose penned journal provided the majority of our knowledge of the geographically vast and historically influential Bering Expedition, Steller was not a skilled, or even competent, artist, as he himself acknowledged (Stejneger, 1936). As a precondition of participation in the Expedition (something he wanted very much), Steller asked to be accompanied by a competent artist (Stejneger, 1936). That demand, fulfilled, recognized the enormous contribution of artists to scientific expeditions (McAleer and Rigby, 2017), and to science as a whole, during eras prior to the 19th-century invention of photography that eventually rendered the competent artist–scientist dispensable and contributed to the estrangement of art from science. *Wunderkammer: Boundaryless Plants* conflated art and science explorations of multilayered and complicated, universal issues played out in a little-known, remote geography. It demonstrated that digital photography and image-clarifying software apps on smart phones and tablets can be used in real time by contemporary scientists to creatively document and communicate findings even on remote, uninhabited islands (Figure 1). Nevertheless, as suggested by Carlson (2017), while digital imaging has profoundly expanded potentialities of scientific research, some capabilities provided by traditional illustration procedures may be lost due to "distortions and visual limitations that single-perspective (i.e., digital or photographic) imagery produces…revert[ing] the visual representation of data back to uninformed, surficial 'snapshots' of incomplete objects" (p. 269).

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Scientific Knowledge, Artistic Creativity and Pedagogical Reform: The Botanical Wall Chart

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Type the phrase "vintage botanical wallchart" into your browser and a plethora of old-style, poster-sized plant illustrations appear. A closer look will reveal original botany wallcharts from the late 1800s selling for around $1500. Updated reprints from the 1960s command anywhere from $200 to $600. Far more money than one would have spent in 1969 when Carolina Biological sold the same charts for $5 (Carolina Biological Supply, 1969).

Regardless of their age, the wallcharts will show use: nicked corners, folds, taped repairs, and penciled notes around the edges. While the resurgence of interest in wallcharts centers on aesthetics, there is historical significance as well, because the botany wallchart represents an early blending of artistry, careful examination of plant morphology and life cycles, and teaching pedagogy.

Mainly designed and printed in Germany and France, wallcharts typically measured 34 × 45 inches. Wooden dowels were inserted in a sleeve at the top and bottom of the chart and from the top roller, heavy string was attached to hang the wall chart. The instructor only needed to supply a nail. Botanical illustrator Heinrich Jung boasted that the size and quality of his wallcharts were of such high grade that all students could recognize his plants from any seat in the classroom (Bucchi, 1998).

Wallcharts occupied a prominent position as curriculum aids from 1820 to about 1920 (Bucchi, 1998). While many of them hung in classrooms and laboratories, other wallcharts helped popularize science in museums and public lectures. As an alternative way to view plants, W. Gardiner stated in his 1904 book detailing the Botanical Museum of the University of Cambridge, "Wallcharts do much to decorate and liven the whole collection,

which might otherwise stand in some danger of being deadened and overweighted by the presence of many dried specimens" (Gardiner, 1904).

German charts were highly valued. There were few American-made wallcharts available in the late 1800s, and even with differences in plant species between the two countries, American botany departments seemed quite content with the German wallcharts, even if they were only accompanied with pamphlets written in a foreign language.

There are several reasons why botanical wallcharts proved so popular. First, improved printing techniques in the early 1800s resulted in high-quality color wallcharts at affordable prices. Germany became the market leader, especially in the late 1800s (Van der Schueren, 2011).

Second, the expansion of European and American education systems during the 1800s led to more students in the biological sciences and natural history. Although the number of students grew, funds for microscopes, textbooks, and laboratory materials did not. Most botany departments could not afford microscopes for each student, but they could buy many different wallcharts for the price of one good scope.

Third, with more students, visual aids became an important teaching tool. Educational specialists believed that students should see and handle objects to better develop an understanding of their world. Combining wallcharts and illustrations with lectures was considered more effective than passive learning by lecture only. Even though wallcharts were visual models and not real plants, education departments (and publishers) strongly advocated wall chart images to help with laboratory work.

One of the more popular botany wallchart series resulted from the collaborative work of Heinrich Jung, Gottlieb von Koch, and Friedrich Quentell (hereafter, J-K-Q wallcharts). Von Koch (1849–1914) was a natural historian, painter, assistant to artist and evolutionist Ernst Haeckel, and finally a biology professor in Darmstadt, Germany. His work with Haeckel undoubtedly influenced how von Koch drew plants as an ideal type (Figure 1). Unlike many detailed plant illustrations drawn by artists, plant drawings for educational purposes were manipulated to create an average view of the specimen (Fletcher, 2017). The drawings removed imperfections and simplified tiny anatomic details. The result was a montage of flowering plants with an aesthetic appeal (Laurent, 2016).

With von Koch as illustrator, and Quentell and Jung acting as authors and colleagues, the three created an impressive number of botanical illustrations for their 1902 book, *Neuen Wandtafeln* für *den Unterricht in der Naturgeschichte* (New Wall Charts for Teaching Natural History). The illustrations were converted to large wallcharts by the Formmann and Morian publishing house in Darmstadt. Formmann and Morian went out of business after World War II, and Wilhelm and Marie Hagemann acquired the publishing rights of the J-K-Q wallcharts. The Hagemann Company in Düsseldorf updated and refreshed the J-K-Q charts but kept them stylistically true to the original wallcharts. The newer editions were made available in the 1950s through the 1980s.

Figure 1. *Rye grass wall chart (Heinrich Jung, Gottlieb von Koch, and Friedrich Quentell) showing large and simplified plant drawings on one poster. Published by Hagemann, Düsseldorf, Germany, 1960s. [Author's personal collection / Photo by author]*

The J-K-Q wallcharts were unique due to von Koch's use of a black background, much like a blackboard (*wandtafel*). Artistically, drawings of large and colorful plants with spacing between them provide contrast. Combining spacing with a black background creates more spatial depth, which makes it easier to see the plants from a distance.

Wallcharts, however, were not without early controversy. Naturalists were torn about the purpose of wallcharts—were they simply visuals that provided an aesthetic appeal or was their purpose to help in the pursuit of botany proper? During the early- to mid-1800s, some believed that the eye was the inlet to knowledge. With this view, botanical wallcharts would help govern learning. Others felt that the brain was the principal gatherer of knowledge and could best be aided with lectures.

Wallchart antagonists declared that charts, while pleasant to look at, were designed for superficial learning—too much visual pleasure took the place of rational learning by reading and thereby sparked no interest in botany as a profession. Proponents of wallcharts argued that the aim of visual materials was for students to build their observation skills for the scientific study of plants in the field and laboratory. This was also the opinion of many science promoters who gave public lectures (Secord, 2002).

English botanist Edwin Lee claimed in the *Naturalist* in 1838 that potential naturalists were more apt to be led to the path of science by using attention-grabbing pictures (Lee, 1838). In response, naturalist Peter Rylands argued that visuals of plants made students too dependent on them for classification and led to unscientific practice. Students, he argued, should use written descriptions that required knowledge about technical plant anatomy terminology. Once mastering this, good observation skills would follow (Rylands, 1838).

More in tune with good teaching practices, many botany instructors did not use wallcharts to strictly establish a "botany by pictures" course, but integrated illustrations with actual specimens. In addition, many instructors believed that mastering the technical terms associated with plants was made easier with

wallcharts and other botany illustrations. By the late 1800s, most science departments placed pedagogical emphasis on visuals for student success (Bucchi, 1998).

Over time, wallcharts gave way to lantern slides, early versions of 35-mm acetate slides. The slides consisted of hand-painted images on a piece of large glass. The images were projected on a screen with the use of a magic lantern, the forerunner to the modern slide projector. Wallcharts, though, did not suddenly disappear. Wallcharts still held an advantage in that they were less expensive than slides. The German graphic arts workmanship continued to produce highly scientific visuals, and with many countries still recovering from WWI, educational institutions were seriously underfunded and stuck with their wallcharts.

Wallcharts also helped with laboratory work for an obvious reason: since lantern slide projection required a darkened room, students had trouble taking notes and could not review the slide at his or her own leisure (Noé, 1928). Large charts allowed students to compare what was seen in the microscope or dissecting tray to the chart image in a room filled with light.

American biological supply companies such as A. J. Nystrom and Denoyer-Geppert continued advertising J-K-Q charts in the 1950s and 1960s. A Denoyer-Geppert advertisement in the *American Biology Teacher* in 1954 assured teachers that updated J-K-Q botany wallcharts were still available, with all charts providing "outstanding combinations of beauty and instructional effectiveness" (ABT, 1954). The eventual demise for botany wallcharts was the emergence of the overhead projector in the 1960s.

Today, wallcharts are collector's items or still languishing in storage cabinets, long forgotten how they contributed to botany and the start of *Anschauungsunterricht*−teaching through images.

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Illuminations: Past, Present, and Future of Fern Research

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This article is about a tripartite environmental art exhibition is emerging from a research-based creative collaboration between Dornith Doherty, artist and professor at the University of North Texas; Dr. Alejandra Vasco, Research Botanist; Ana Niño, Librarian; and Tiana Rehman, Herbarium Director, at the Botanical Research Institute of Texas (BRIT) at the Fort Worth Botanic Garden (FWBG). This paper describes the installed artworks and reflects on the experiences of developing and presenting an integrated arts-science exhibition.

PROJECT DESCRIPTION

Illuminations was on view at BRIT from January through June 2023. Dornith Doherty was an artist affiliate with BRIT from July 2021 through January 2023, and during her residency, she worked with Alejandra Vasco, Ana Niño, and Tiana Rehman to research primary source materials housed in the BRIT Library and Herbarium. In the resulting exhibition, Dornith presented new large-scale artworks installed in the BRIT Madeline R. Samples Exhibit Hall and throughout the BRIT Building.

Accompanying the artworks were vitrines containing archival materials from the library, the herbarium, and the *Ferns of Colombia* project, a National Science Foundation–funded collaborative study of fern diversity in Colombia. The co-exhibition of new artworks alongside the primary research materials from which they were derived highlighted the remarkable, irreplaceable record of botanical diversity captured by the *Ferns of Colombia* field research and preserved for the future by the BRIT Library and Herbarium. The installation of the artworks onto windows and projections onto walls in the gallery and throughout the BRIT research building established visual proximity to original materials—prompting dialogue between scientific, archival, and artistic disciplines. The three sections of the exhibition can be divided into temporal themes: artworks that engage with the past, chronicle the present, and project our possible ecological futures.

Past

On the second floor facing the entrance to the BRIT Herbarium, large-scale transparencies (6.5 feet high × 14 feet wide) were installed directly onto existing windows (Figure 1A). Dornith created these brilliantly colored digital collages by photographing diaphanized plant slides archived in the BRIT Herbarium and originally prepared

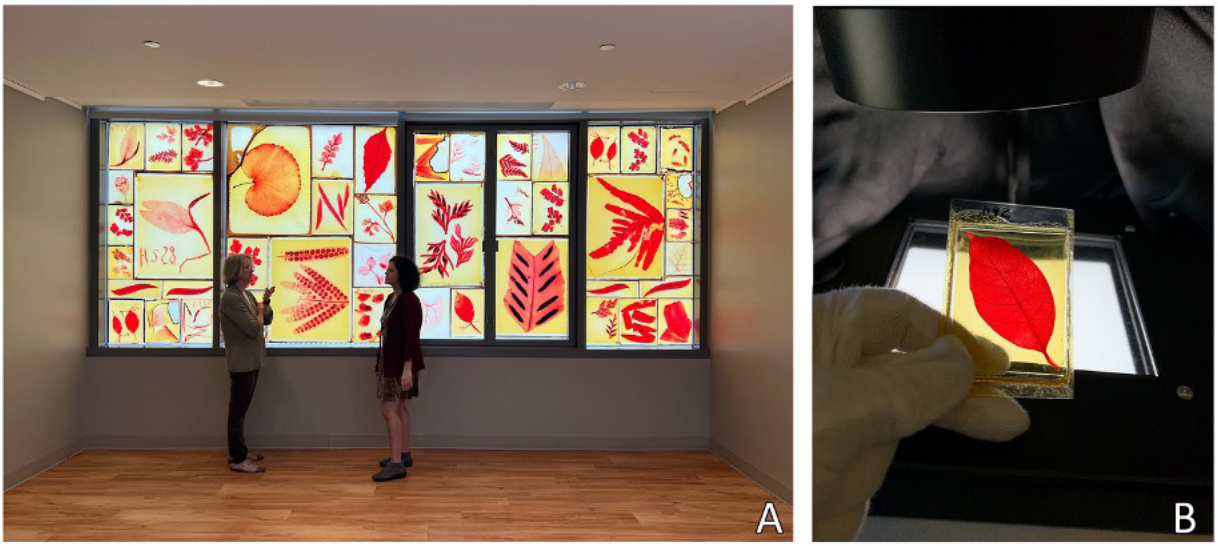

Figure 1. *(A) Anthenaeum, Dornith Doherty (2023), translucent artwork installed onto alcove windows with Dornith Doherty (left) and Ana Niño (right) in the foreground. (B) Diaphanized plant slide made by Dr. Howard Arnott.*

around 1956 by noted botanist and imaging specialist Dr. Howard Arnott (Figure 1B). Located along the corridor nearby are vitrines containing Arnott's field journals, original diaphanized plant slides, and his graduate-level academic writings. This interdisciplinary presentation of artistic practice alongside scientific research materials prompts meditation on the material traces of botanical life from the microscopic details of individual leaves to the universal importance of preserving and studying the world's plant diversity.

Present

Global biodiversity is threatened by climate change and accelerating habitat loss, and exceptionally diverse tropical regions are particularly vulnerable. Colombia is one of the most biodiverse countries on Earth, but knowledge about its biota is taxonomically biased, and many groups remain poorly understood. Ferns are one of these conspicuous but understudied groups; despite having the most species of any country in the Americas, Colombia lacks a complete fern flora, and most species remain poorly known.

As the Ferns of Colombia team co-led by Alejandra works in the field, specimens are collected and pressed between sheets of newspapers and archived to be further studied in the BRIT Herbarium. Inspired by the poetic possibilities of the chance juxtapositions created when diverse ferns are pressed to dry on top of the daily news of Colombia, Dornith created artworks that mingle the cultural and natural histories of Colombia—chronicling the present time of urgent plant discovery in an era of declining biodiversity, political instability, and the longing for peace. More than 100 of these plant/news time capsules were illuminated with light boxes, photographed, and digitally edited, rendering the dried ferns into ghostly blue silhouettes floating above the background of contemporaneous news to create the 12 final artworks included in the exhibition (Figure 2). Some of the artworks highlight species not described by science and species not collected in over 150 years in one of the most diverse areas on Earth. The bilingual presentation of all exhibition materials in English and Spanish invited cross-cultural dialogue and connections between art, science, culture, and technology, through multilingual lectures, social media interactions, and tours.

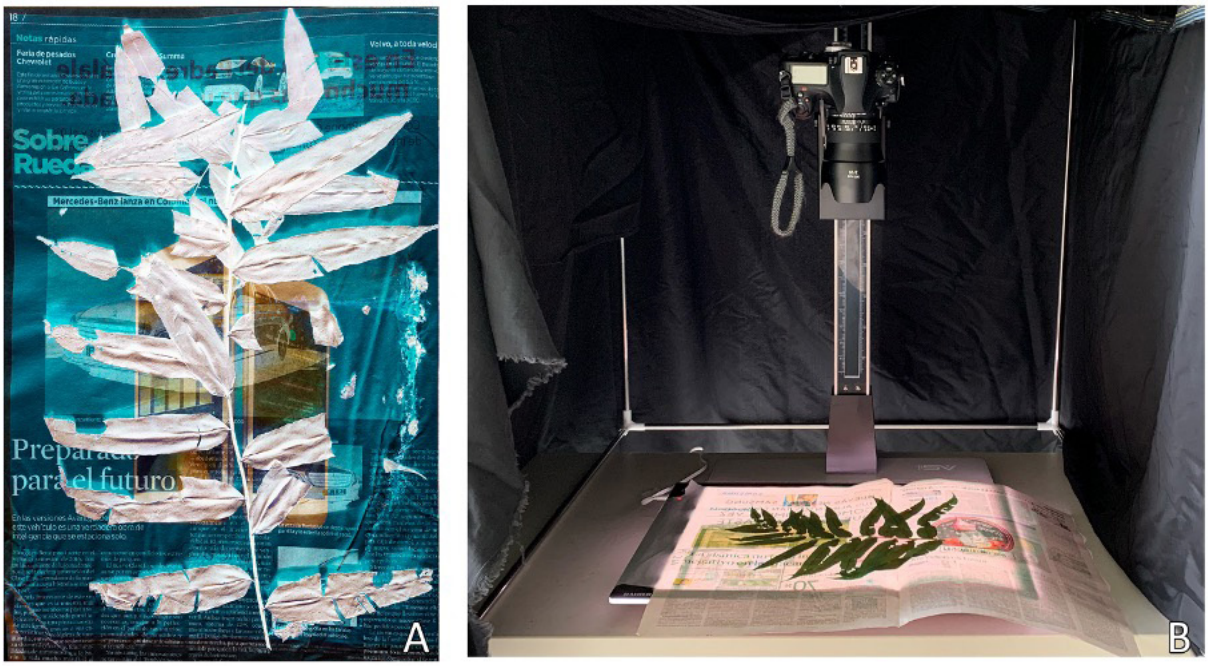

Figure 2. *(A)* Parablechnum lechleri | *Preparing for the Future, Dornith Doherty (2023). (B) Fern specimen collected by the* Ferns of Colombia *project in the artist's portable digitization studio.*

Future

Completing the tripartite exhibition was a digital animation Dornith created from DNA sequences and specimen silhouettes from the *Ferns of Colombia* project. The genomic data (DNA sequences) that the *Ferns of Colombia* team is generating are critical for resolving taxonomic problems and placing Colombian fern diversity in an evolutionary context. These data are currently unavailable for most of Colombia's fern species. The animation created by Dornith was projected onto the exterior of the BRIT building, identifying the building as a site of specimen-focused cutting-edge research while proposing a future in which ecosystem rescue and revival is possible through equitable sharing of knowledge (Figure 3A).

By displaying artworks through three distinct methods, the exhibition offered audiences different paths of engagement with the nature and complexities of botanical research and preservation—inviting guests to explore spaces in the building normally only occupied by researchers.

OUTREACH

Initially, discussions about the intended audience were generalized to FWBG visitors, school students, and invited guests attending the opening reception, consisting of family, friends, botanists, and business associates of the collaborators. An estimated 250 to 300 in-person visitors were expected to view the exhibit. There were two main challenges to reaching a broad audience in this research space: weekend closures, and the tendency for Garden guests to overlook a visit to the BRIT building. Outreach efforts included an exhibition brochure and invitation card, YouTube videos, social media posts, group and self-guided tours, and two special gallery events: an opening reception and participation in a city-wide Spring Gallery Night (Fort Worth Art Dealers Association, 2023).

A panel discussion was held during the opening reception where the four collaborators discussed their experiences in developing this

Figure 3. *(A)* Ferns of Colombia*, Dornith Doherty (2023), digital animation projected onto the exterior of the BRIT building. (B) Panel discussion during opening night.*

science-art collaboration (Figure 3B). The discussion was organized by BRIT Librarian Ana Niño and is available to view on the FWBG YouTube channel (https://www.youtube.com/watch?v=QLEYprXqubA).

More than 400 guests physically visited the exhibition, of which more than 140 attended the opening reception and panel discussion. In addition, an online lecture about the exhibition was viewed by 100 people; the exhibition received reviews in magazines (e.g., PaperCity, Madeworthy, and Patron); and social media posts (both from personal and institutional accounts) reached over 8000 impressions.

Audience feedback has been of the highest praise. The guestbook is filled with comments like "Wonderful exhibit, beautiful work" and "I love the pieces – all the interplay of elements!" Visitors and colleagues alike have also shared many kind words with collaborators. The exhibition is documented on the FWBG website (fwbg.org/events/illuminations-fern/), the *Ferns of Colombia* website (fernsofcolombia.com), and the artist's website (dornithdoherty.com).

REFLECTIONS

Dornith Doherty
Artist and Photography Professor

This project was made possible by the professional and personal generosity of my collaborators at BRIT. Their openness to collaboration allowed me to construct a small temporary studio in the herbarium and access to the *Ferns of Colombia* specimens, the mounted glass scientific slides in the herbarium, and the archival materials in the library. Casual lunch meetings filled with open-ended conversation facilitated reflection and resulted in a fertile collaborative environment.

I spent several months researching and photographing unaccessioned specimens in the herbarium and then worked with those digital files to create collages and animations in my studio. Ferns were the dominant lineage of vascular plants on Earth for millions of years before seed-bearing plants became the most diverse and common plants in most ecosystems. As such, ferns have evolved remarkable adaptations to extreme conditions. Their resilience in the face of environmental change, and the hope that resilience inspires, became a key metaphor for my project.

The biggest challenge I faced was the elimination of the gallery program at BRIT and the departure of the curator. This placed extra communication, budgetary, and planning responsibilities on my collaborators. A few exhibition ideas were not possible because the BRIT gallery space was used for private rental events.

The limitations related to the use of the gallery space led me to create artistic interventions throughout the building, which included the data animation projection onto the exterior of the building and the installation of the transparent collages onto the windows. This resulted in a more dynamic exhibition, which was a positive experience.

Alejandra Vasco
Research Botanist and Fern Program Leader at BRIT

The exhibition started as an exploration by Dornith of the botanical artifacts at the BRIT Herbarium and Library. She wanted to speak to the researchers who use these collections, and soon enough, our interactions and our fern research wound up inspiring the Present and Future parts of the exhibition. After arriving from the NSF-funded *Ferns of Colombia* field expeditions, Dornith and I would meet over lunch, and I would share experiences about field work, the many intriguing specimens collected, the forests, the food, the researchers and students, and the struggles of the people living and preserving their territories. These lunches catalyzed ideas on how art could tell the story of research and botanical preservation, while conveying the urgency of studying these ecosystems and species in the face of biodiversity loss and climate change.

It was a delight to interact with Dornith. She is fascinated and curious about the work researchers do to document and preserve biodiversity. It was mesmerizing to see how the *Ferns of Colombia* stories and herbarium specimens were transformed through Dornith's artworks and to learn from the many different layers and meanings physical artifacts of biodiversity preservation have. During the discussion we had at the exhibition opening, I also found it interesting how Dornith's artworks allowed the public to open up and be more comfortable asking questions not only about the art, but also about the science, the collections, and research in the tropics.

Tiana Rehman
Herbarium Director

Herbaria protect specimens that serve as the foundation for investigation across spatial and temporal scales, whose stories are activated by their users. Dornith's respectful approach to the collections quickly established a relationship of trust, allowing her freedom to explore our unaccessioned holdings and uncover her own stories. We were habituated to the sight of Dornith's changing studio set-up in the herbarium, sharing our delight over her discoveries at our bilingual lunches. Initially, we shared big ideas for communicating the value of natural history collections to our community through an exhibition that reached across FWBG spaces, and although logistical and budgetary restraints limited our reach to the interior/exterior spaces of the BRIT building, the exhibition allowed us to engage new guests with our collections.

Dornith drew attention to the beauty and utility of our legacy collections through the Past showcase of the Howard Arnott microscope slides collection, whose acquisition itself was a race against time (acquisition from garage storage, post-collector retirement). The contrast of all the data, images, and insight into contemporary botanical research, with the more investigative work it took to recreate these connections for the Past portion of the exhibit, was particularly illuminating. The concept of the 'extended specimen' (Webster, 2017; Lendemer et al., 2020) connects a single specimen with other related existing and yet-to-be-created

images, data, analyses, and object resources, allowing us a more complete understanding of organisms and their biological communities. Dornith's careful documentation of the specimen origin of these art derivatives adds another layer to our understanding of these specimens and the social context in which they were collected.

Kimberlie Sasan
BRIT Research Assistant

Would we do it again? I certainly hope we would and use what we learned to make the next exhibition even better, but there is something special about pulling together and blazing new trails through the unknown. I remember how it taxed each of us beyond our expectations, and how that might make us hesitant to go into such a project again. Yet, the bond between the artist, researchers, and librarian is stronger for having had those challenges and overcome them. I think they each gained personally more than the organization did. As an audience member, I still reflect on the images of the art and how they humanize the work I do at BRIT every day. I contemplate the fern specimens I touch being in newspapers printed and read by Colombians, and together how we are rescuing ferns, and with them important ecosystems, without even knowing each other.

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The Four Noble Ones: Significant Cultural Elements Bridging Chinese Painting and Botanical Sciences


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Plum blossom, orchid, bamboo, and chrysanthemum come together to form the Four Noble Ones (also known as the Four Gentlemen; Chinese: 四君子). These four plants symbolize the ideal virtues of a person: perseverance, nobility, righteousness, and humility. The prominent use of these plants in art forms, including poetry, literature, and painting, emphasizes their importance in Chinese and East Asian cultures. In addition to their use in art, the Four Noble Ones serve important roles in other avenues of daily life, such as medicine, building materials, and traditional cuisine. The Four Noble Ones represent an excellent example of bridging art and botany, and they emphasize the significant role of plants in people's spiritual life and well-being. In this essay, we focus on the Four Noble Ones as recurrent botanical subjects in Chinese brush painting, discuss their cultural significance and importance in everyday life as well as efforts to understand and preserve the biodiversity of these taxa.

THE FOUR NOBLE ONES IN CHINESE BRUSH PAINTING

Illustrations of the Four Noble Ones belong to bird-and-flower painting, a genre that originated in the Tang dynasty (618–907), reached its peak in the Song dynasty (960–1279), and continues to flourish in the present day. The Four Noble Ones are depicted in two main styles: *gongbi* (工笔; i.e., detailed painting) and *xieyi* (写意; i.e., freestyle painting).

Gongbi uses highly detailed brush strokes and is often colored. Painting plants in *gongbi*-style is similar to that of western botanical drawings, in that they closely resemble the real morphology of a plant. Figure 1a shows a *gongbi*-style painting of a plum branch by Ma Lin (1195–1264). Given the detailed depiction, the cultivar of the plum is presumed to be '*green calyx*'. Figure 1b shows Ma Lin's painting of orchid, species *Cymbidium faberi*. Figure 1c, titled "Finches and Bamboo" by Emperor Huizong of Song (1082–1135),

Figure 1 *Gongbi-style paintings of the Four Noble Ones. (a) Plum blossom by Ma Lin; (b) orchid by Ma Lin; (c) "Finches and Bamboo" by Emperor Huizong of Song; (d) "A Cluster of Chrysanthemums" by an anonymous artist from Yuan dynasty. Image credits: (a) The Palace Museum (Beijing); (b) The Metropolitan Museum of Art, New York (C. C. Wang Family Collection); (c) The Metropolitan Museum of Art, New York (John M. Crawford Jr. Collection); (d) the National Palace Museum (Taipei).*

showcases the meticulous style of bird-and-flower painting. "A Cluster of Chrysanthemums" by an anonymous artist from the Yuan dynasty (1271–1368) is shown in Figure 1d; the cultivar names are noted in the painting, emphasizing the realistic appearance of plants painted.

Xieyi emphasizes the spiritual aspect of the subject and often uses monochrome brushstrokes. A painting done in the *xieyi*-style may represent an abstract idea. The plum painting by Wang Mian (1287–1359) depicts petals using dark ink (Figure 2a); Wang believed that the omission of color exalts the purity of the plum blossom. Figure 2b shows a *xieyi*-style painting of orchid by Zheng

Figure 2. *Xieyi-style paintings of the Four Noble Ones. (a) Ink plum by Wang Mian; (b) orchid by Zheng Sixiao; (c) "Bamboo in Monochrome Ink" by Wen Tong; (d) chrysanthemum by Shen Zhou. Image credits: (a) The Palace Museum (Beijing); (b) https://commons.wikimedia.org/wiki/ File:Zheng_Sixiao_-_Orchid_-_Google_Art_Project.jpg; (c-d) the National Palace Museum (Taipei).*

Sixiao (1241–1318); Zheng used a rootless plant to symbolize the unjust appropriation of his homeland's territory. "Bamboo in Monochrome Ink" by Wen Tong (1018–1079) is shown in Figure 2c. Wen invented the genre of ink bamboo painting and used light and dark ink tones to distinguish two leaf sides. Figure 2d shows the ink chrysanthemum by Shen Zhou (1427–1507); the ink tonal variations impart a sense of weathered crispness to the blossoms.

Plum Blossom

Plum (*Prunus mume*; Rosaceae), also known as *mei* (梅), is a small deciduous tree native to China that has been cultivated for more than 3000 years (Li and Liu, 2011; Zhang et al., 2012). The flowers are white, pink, or red, and bloom during late winter and early spring. *Mei*'s resistance to cold weather resembles a person's perseverance (Bickford, 1985). An influential contribution to the history of *mei* painting is the invention of the

"ink plum" style (an example is shown in Figure 2a). The ink tonal variation captures the nuances of color, making "ink plum" highly favored among the scholar-official class (Bickford, 1996). In addition to its ornamental values, *mei* was cultivated for fruit harvesting. The common *mei* products include *mei* wine, salted *mei*, and *mei* jam (Li and Liu, 2011).

The dedicated efforts to breed plum trees contribute to the proliferation of *mei* cultivars. *Mei Treatise* by Fan (1186)—the first monograph of *mei* in China—noted 10 cultivars. As of 2011, there are 381 internationally registered cultivars (Li and Liu, 2011). Recent molecular studies revealed plum's diversity and the genetic basis underlying its hardy character. The genetic relationships among *mei* cultivars were evaluated using molecular markers (Fang et al., 2006). Zhang et al. (2012) sequenced the genome of *Prunus mume* and identified genes contributing to early dormancy release. Transgenic tobacco plants expressing the *P. mume* dehydrin genes showed enhanced tolerance to cold and drought (Bao et al., 2017).

Mei gardens exemplify efforts to conserve plum trees in China. Meihua Hill, located in Nanjing, covers over 100 hectares and contains more than 40,000 plum trees of over 300 cultivars (Li and Liu, 2011). Meihua Hill is also renowned for hosting the International Plum Blossom Festival. The East Lake Mei Garden in Wuhan contains over 200 *mei* cultivars and is home to the Mei Flower Research Center of China and the National Mei Flower Germplasm Conservation Garden (Li and Liu, 2011).

Orchid

The genus *Cymbidium* of the family Orchidaceae includes approximately 80 species of orchids, which are mainly distributed in the subtropical and tropical regions of Asia and northern Australia (Zhang et al., 2021). Flora of China recorded 49 species, including 19 endemic species, in China (eFloras, 2008). Many species have been cultivated as ornamentals for centuries, including *C. ensifloium*, *C. goeringii*, *C. sinense*, and *C. torisepalum*. Nowadays, *Cymbidium* plays an important role in the global orchid market (Yuan et al., 2021).

Orchid represents nobility in Chinese culture (Siu, 2018). The plants grow in the remote forest and valley, where the flower is known for a pleasant fragrance. Confucius (551–479 BC) believed that the characteristics of orchids resemble a noble person's self-cultivation, who will not abandon moral principles even in destitution (Siu, 2018). Orchid became an independent subject of Chinese brush painting during the Song dynasty, when *gongbi*-style was prevalent. Following the Mongol conquest of the Song, China entered a turbulent period (1235–1279). Many scholars refused to serve in the new regime, and painting of "ink orchid" became a metaphor for their loyalty and patriotism.

Recent genetic studies of *Cymbidium* have used various markers to understand the diversity of orchid cultivars (Huang et al., 2010). The molecular mechanisms of leaf color variation and floral development have been studied (Yu et al., 2020; Yang et al., 2022). Two main approaches, in-situ and ex-situ conservation, have been used to preserve *Cymbidium* diversity in China. By 2018, over 2750 nature reserves were established throughout China, many renowned for their rich orchid diversity (Zhou et al., 2021). For example, *C. elegans*, *C. hookerianum*, *C. tigrinum*, and *C. tracyanum* are protected in situ at the Gaoligongshan National Nature Reserve, and *C. nanulum* at the Yachang Orchid National Nature Reserve. Several botanical gardens in China, including Xishuangbanna Tropical Botanical Garden and Kunming Botanical Garden, are well known for their ex-situ efforts to conserve orchids outside their natural areas. Of the 51 *Cymbidium* species surveyed by Liu et al. (2020), 43 are protected in botanical gardens.

Bamboo

Bamboo, which makes up the subfamily Bambusoideae of the grass family (Poaceae), symbolizes righteousness and humility among the Four Noble Ones (Lai, 2012; Cheng, 2020). Bamboo originated in southeast Asia, but it is common across Asia, Africa, and Latin America. There are currently more than 1400 recognized species of bamboo (Kelchner and Bamboo Phylogeny Group, 2013). Bamboo is a cosmopolitan group, with many species that have been able to adapt to new environments (Yang et al., 2008). Although the appearance of bamboo in painting may be hard to date exactly, Wang (1948) suggests that bamboo first shows up in the background of religious icons and figure paintings. Early depictions of bamboo outline the leaves and stems of the plant with occasional added color, while later styles painted stems and leaves with ink but no outline (Wang, 1948).

Bamboo is valued in people's daily lives because of its strength and flexibility, as well as its quick growing cycle (Dlamini et al., 2021). It is also a useful socioeconomic resource across many countries in Asia, serving as food and providing building material for structures such as scaffolding, bridges, and buildings, as well as being used to make instruments and utensils (Yang et al., 2004; Mera and Xu, 2014). Bamboo has become a popular subject of materials science research, because scientists are exploring bamboo composites as an alternative to wood (Nkeuwa et al., 2022). Xuan paper, made from bamboo pulp, is popularly used for calligraphy and painting (Yang et al., 2008). In addition to the many resources provided by bamboo, it has a long history of being used as part of classical Chinese gardens, and it was first recorded as being an essential part of the early Zhou dynasty (1046–256 BC) gardens (Yun, 2014).

The depletion of bamboo resources has led to both ex-situ and in-situ conservation efforts. Bamboo gardens, as well as the establishment of reserves such as the Natural Reserve in Xishuangbanna, are in-situ approaches to conserving native species in their natural habitats (Yang et al., 2008). Because of its extensive rhizome system and rapid growth, bamboo conservation in these areas also provides many ecological benefits, including erosion prevention, carbon sequestration, water conservation, and use as windbreaks (Song et al., 2011; Tardio et al., 2018; Dlamini et al., 2021). Botanical gardens such as Zhejiang Bamboo Botanic Garden, Bamboo Garden of Fuzhou Arboretum, and Xishuangbanna Tropical Botanical Gardens are ex-situ efforts to conserve biodiversity (Yang et al., 2008).

Chrysanthemum

Inflorescences from the genus *Chrysanthemum* (Asteraceae) are considered a symbol of nobility, due to their ability to bloom in chilly autumn weather (Shahrajabian et al., 2019). There are approximately 40 species (Liu et al., 2012). In ancient China, they were also often associated with the poet Tao Yuanming (365–427), who was known to have a small garden of chrysanthemums and was frequently painted with blooms in his hand (Yuan, 2009).

This genus is native to China and was first cultivated in the 15th century BC as an herb before cultivation of the wild *Chrysanthemum morifolium* first took off during the Ming (1368–1644) and Qing (1636–1912) dynasties (Imtiaz et al., 2019; Yuan et al., 2020). It has since served as an important component of traditional Chinese medicine for the past 2200 years and has been used for the treatment of fever, headache, sore throat, and many other common ailments (Yuan et al., 2020; Hao et al., 2022). The flower head of *C. morifolium* has been used as a dietary supplement

for thousands of years in China, most popularly as tea but also in wine, cakes, and other dishes (Yuan et al., 2020).

Chrysanthemum's popularity eventually led it to dominate the horticulture market as the second most important floriculture crop after rose (Shinoyama et al., 2012). Chrysanthemum breeding has led to many varieties and eight main cultivars with different geographic origins (Liu et al., 2012; Hao et al., 2022). Increasing market demands for new varieties have led to improved breeding techniques that alter features such as floret number, petal size, and floral organ (Su et al., 2019). The worldwide popularity of chrysanthemums in the floral industry has motivated scientists to better understand the genetic diversity of cultivars to promote conservation. Breeders have also tried to determine cultivars that are least susceptible to white rust, caused by the fungus *Puccinia horiana,* which can easily spread if not contained quickly (Lu et al., 2018). Efforts to conserve genetic resources and optimize production systems can also help promote environmentally friendly horticulture practices (Zhao et al., 2009).

CONCLUSIONS

The Four Noble Ones are cherished botanical subjects of traditional Chinese brush painting that offer insight into the cultural significance of these four plants in China, as well as many other Asian countries. Through the use of both *gongbi* and *xieyi* painting styles, artists honor the Four Noble Ones and the ideal values they represent, in addition to the many roles they serve in everyday lives. Modern efforts to conserve the diversity of these plants take many forms. We hope this essay has conveyed a meaningful example of the deep connection between art and botany in Chinese culture.

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Art Is Not Only About Flowers: Ferns as a Source of Inspiration for Artists

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FERNTASTIC PLANTS

Van Gogh's sunflowers, Monet's water lilies, Tarsila do Amaral's manacs, and a whole host of other flowering plants have been and continue to be a huge source of inspiration for artwork around the world. But artists cannot live on flowers alone. Ferns were the inspiration for the sculptures and photographs of Karl Blossfeldt (1865–1932), a German artist whose organic ornaments heavily influenced the world of art and design. The beauty of ferns was also captured in a breathtaking series of photographs by Italian photographer Paolo Monti (1908–1982) titled "Astratte Felci e Foglie" (Abstract Ferns and Leaves), and the beautiful mosaic "Mosaiksupraporte Farnkraut" (Fern herb mosaic overhangs) by Ernst Paar (1953/1954) in a housing complex in Vienna, Austria. These are just some examples of fern-inspired artistic expression around the world.

Ferns also play a central role in the culture and artistic expression of the Maori, the indigenous Polynesian people of New Zealand (Figure 1). Their word for the spiral shape of young unfurling fern fronds is "koru" and holds immense symbolism in their culture.

Although there are many interpretations of the meaning of "koru," Henry and Pene (2001) wrote that the basic beliefs at the heart of "koru" revolve around "*Io, The Supreme Being or origin of all life, from which came Papatuanuku, the earth mother and Ranginui, the sky* father…."

This essay highlights two artworks inspired by ferns—plants that are often overlooked in favor of their flower-bearing counterparts. However, art inspired by these plants goes beyond paintings to include objects, sculptures, photographs, and representation in buildings in which they appear. This subject is vast and will not be exhausted here. Against a backdrop of the arts, my goal is to evoke a more poetic perception of ferns that inspires the adoration these *ferntastic* plants deserve.

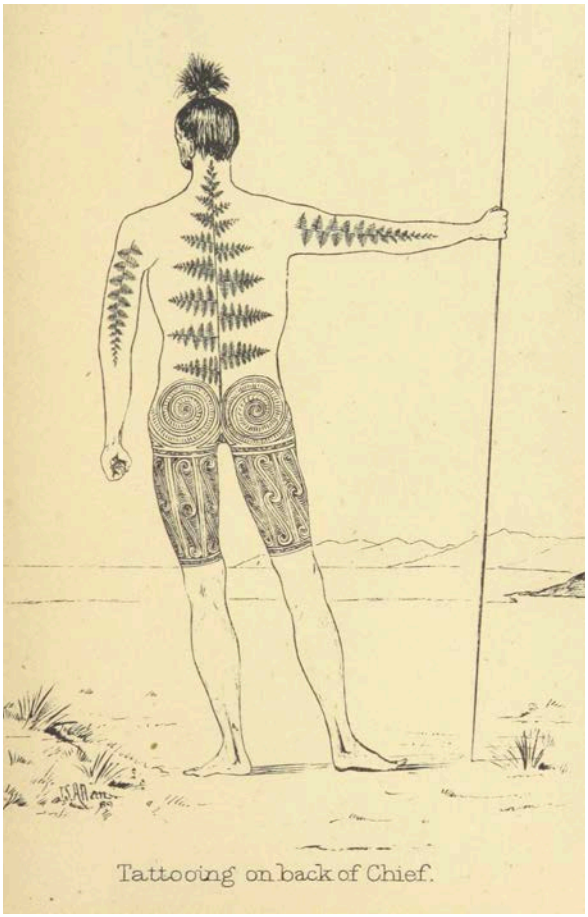

Figure 1. *Image taken from page 109 of "Illustrations prepared for White's Ancient History of the Maori", 1891. The British Library, No restrictions, via Wikimedia Commons.*

CRAZY ABOUT FERNS!

The Victorian Era, as the reign of Queen Victoria of England is known (1837–1901), was marked by so-called "fern fever" or pteridomania, an obsession with collecting and growing ferns and owning objects with pictures of them (Duggins, 2015). "The Fern Gatherer" (1877), painted by Charles Sillem Lidderdale (1830–1895) (Figure 2), epitomizes this era when fascination for all things fern reigned.

Are ferns still glamorous? According to McCulloch-Jones et al. (2021), there is still a large commercial market for ornamental ferns

Figure 2. *The Fern Gatherer, 1877. Charles Sillem Lidderdale. Public domain, via Wikimedia Commons.*

from Asia, Australia, and New Zealand, with an estimated annual commercial value of US$150 to 300 million!

FERN FLOWER POWER

The fact that ferns have no flowers or seeds confused their first observers, who invented a myriad of, at times highly unlikely, stories to explain the biology of these plants, especially in European countries. In these tales, ferns' flowers and seeds could only be seen and gathered on certain special occasions and anyone who possessed them would be blessed with supernatural powers, invisibility, extraordinary strength, and wisdom (May, 1978).

According to the Polish legend "Fern Flower," wild ferns produce magical flowers on the evening of the summer solstice. This popular belief is ubiquitous in paintings and illustrations in adult and children's books across Poland. It was depicted in the paintings "Kwiat paproci" (Fern Flower, 1900; Figure 3) by Antoni Piotrowski (1853–1924) and "Saint John's Eve" (1875) by Witold Pruszkowski (1846–1896), among others.

Plant reproduction remains a difficult subject to understand in botany teaching and scientific divulgation, largely because of the challenges involved in observing plant phenomena and the complexity of the terminology (Barbosa et al., 2021). I often hear my students say, "Professor, I always thought those little brown balls (sori) on fern leaves were fungi or a disease...."

BUILDING BRIDGES

The art discussed here can lay the groundwork for dialogue between art, culture, and botany and two pertinent themes: namely botanical imperception and plant reproduction. In the first case, depending on time and space, imperception can be accentuated in plants such as ferns, which are often overlooked. Lidderdale's painting "The Fern Gatherer" reflects a time in European history when ferns were revered. In contemplating this work of art, our thoughts travel to other peoples who have ferns engrained in their culture, such as the Maori, and we are enthralled by the captivating beauty of these plants and learn to admire them.

In terms of fern reproduction, their lack of flowers, fruits, and seeds still confuses people, who find it difficult to establish parallels with plants that have these structures. Piotrowski's "Kwiat paproci" (Fern Flower) depicts a cultural perception of ferns inspired by popular legends that emerged at a time when little was known about the reproductive biology of ferns, especially among laypeople. At the time, their lack of flowers was explained using other types of knowledge, which should be reflected on by current admirers of the work.

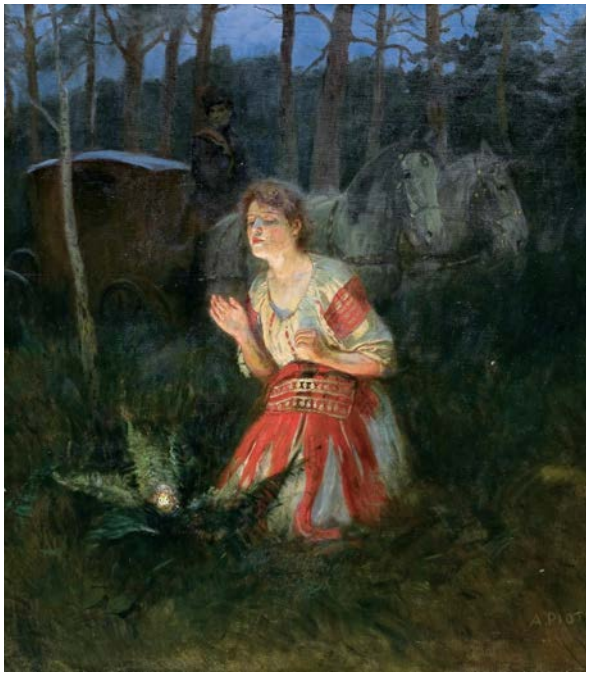

Figure 3. *"Kwiat paproci" (Fern Flower), 1900. Antoni Piotrowski. Public domain, via Wikimedia Commons.*

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The Artist-Scientist Symbiosis: A Dialogue

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The disciplines of art and science have a lot in common in terms of their practice and research processes, a sameness that we have observed and frequently discussed in our artist/mother–scientist/daughter symbiosis. Symbiosis is an intimate and often long-term relationship between two or more organisms, which can range from mutually beneficial to mutually challenging. Our artist-scientist symbiotic relationship has been beneficial, with each of us gaining from the other's insights, expertise, skills, and ways of seeing.

The story of art and the story of science is a story of questions. We are inspired by questions, which we then explore and research by testing ideas, gathering data, drawing conclusions, disseminating ideas, returning to our hypotheses, and beginning again. We identify a problem, and we explore ways of solving it. Some of this exploration involves—requires—play, freedom, and open-mindedness. In the relationship between artist and scientist, we each invite the other to look through a different lens. We each inspire questions from a realm unfamiliar to ourselves.

COLOR THEORY AND PATTERNS ON TREES

[G.S.] While teaching a course on color theory for interior designers, I would emphasize Albert Munsell's color relationships that occur frequently in nature. One color relationship, the split complement, is where you take two complementary colors, such as red and green, but split the green into yellow-green and blue-green. This beautiful color triad could be observed on the lower trunks of royal palm trees on campus, but only after the rain. I observed patterns of grays turning into vibrant reddish-browns, blue-greens, and yellow-greens: a gorgeous example of color harmony. I would instruct my students to run out after a rainstorm to look at these color patterns. I observed this phenomenon and instructed my students to observe this phenomenon, without thinking beyond the pattern of color, or what it was, or why it changed. Years later, when my daughter began studying lichens and immediately sharing what she learned with me, I connected the dots back to that Color Theory course, realizing that it was lichens changing color after being hydrated by rain. My daughter and I have discussed that my observations in my Color Theory class may have

given her the beginnings of what she now terms "the lichen eye." This "lichen eye" is why we see whole worlds of organisms on the surfaces of rocks, trees and soil that most people overlook. One of the common denominators between scientists and artists is that we are acute observers, but the difference in the filters of the artist and scientist is the strength of our relationship.

THE UBER CONVERSATION

[K.S.] During my postdoc in England, I invited my mom to visit me for a long weekend to see a particular art exhibit in London and to visit as many other art museums as possible. To maximize our time, we took Ubers from one art venue to the next. Sitting in the back of the Uber, momentarily freed from any distractions, we could dive deep into conversation. I began by telling my mom about what I was working on in my postdoc. I was attempting to grow lichens in the lab in order to conduct experiments to better understand the mechanisms of the lichen symbiosis. Lichens are complex symbiotic organisms, consisting of a primary fungal and a primary algal or cyanobacterial partner. I described to her how we were growing whole lichens collected directly from the field, as well as isolated cultures of the fungal partner and the algal partner. Part of the challenge of experimental work with lichens is that they tend to grow very slowly, so I was looking for ways to promote lichen growth in the lab. I described how almost anything we tried failed, and how it defied logic since lichens seem to grow so well in challenging environments outside the lab. As we often do, my mom and I began to troubleshoot and brainstorm ideas on possible solutions to create growing conditions for the laboratory lichens.

Brainstorming is a valuable tool in both art and science, because it is an opportunity to explore possibilities without restraint. My mom's artistic practice emboldens childlike and playful questions of "Why?", "What if…?", and "Why not?" While engaged in brainstorming ping-pong, my mom and I discussed the potential use of different substrates and/or media in promoting lichen growth. Many of the potential substrates we could test in the lab quickly ran into affordability or feasibility issues, but the discussion also included the use of ceramics. Ceramics provide a freedom of size, shape, and texture at relatively low cost. My mom's expertise meant she could share the uses of different clays, firing techniques, and impregnating the clays with different materials to create and test substrates with different properties. We also discussed the introduction of wind or other disturbances in the growth chamber—perhaps you need the chaos and imperfections of the natural world to make them succeed in the lab. We even discussed the idea of building a structure around lichens *in situ*, but realized that wouldn't work because it would alter the *in situ* conditions. Each conclusion made us realize we were backing ourselves into a corner, which then reminded me of one of my favorite books from childhood given to me by my mom: *The Salamander Room.* The children's book *The Salamander Room* by Anne Mazer tells the story of a boy who finds a salamander in the woods and brings it home. But the salamander does not thrive, so the boy keeps adding things to his room in an attempt to make it happier: a rock, some leaf litter, a small pool, some insects to feed on, another salamander for company—but the more he added, the more he needed to add to keep everything in balance. By the end of the book, the boy's bedroom has been completely transformed into the forest he collected the salamander from. The lesson of the book is that the best place for a salamander to be a salamander is in its natural environment. For me, during that Uber conversation, the book became a useful metaphor to examine what is gained and lost in our laboratory studies. My mom and I were brainstorming with such enthusiasm and gusto that our Uber driver could not help but also become engaged. He delightedly asked a lot of questions, and commented on how unique our mother-daughter, artist-scientist relationship was. My mom and I simply being ourselves led

to a beautiful interaction with a stranger, and a productive science communication moment in the midst of fun.

Following my mom's visit, I applied a lot of what we discussed, testing a lot of variables in the lab. The more I did so, the more *The Salamander Room* seemed to ring true, and successfully growing lichens or their constituents in the laboratory remains challenging. The artist brings to the dialogue an irreverent acceptance of failing, imperfection, or the stray mark. To the artist, the stray mark is not a lie (or an outlier), it is the truth. It is part of the picture. The more I thought about *The Salamander Room*, the more I wondered whether there could be organisms, like lichen, that defy the lab—and not just in terms of rapidity of growth. If we alter variables enough, have we taken away the conditions that necessitate or facilitate the symbiosis of the lichen, such that the associations we are measuring in the laboratory are no longer the symbioses we set out to test?

LICHEN POETRY AND THE CONCRETE BENCH

[G.S.] The tradition in our family each winter holiday is to gather in Miami, Florida where we make our annual trips to Everglades National Park, Fairchild Tropical Botanical Garden, and sometimes Deering Estate. My daughter Klara and I can often be found with our eyes two to three inches from almost anything, discovering lichens; their patterns and diversity, their interactions, and the surprising variety of substrates they grow on—from the trunks of trees to concrete pavement to recycled-plastic boardwalks.

I have brought this "lichen eye" with me to my artist residency at the Deering Estate. The Deering Estate encompasses the historic home of Charles Deering and the Richmond family, protection of indigenous archeological sites, as well the protected site of threatened south Florida habitats, including pine rocklands, hardwood hammocks, and mangroves. These historic, prehistoric, and natural surroundings have been the subject of many previous artists in residence. I wanted to focus on something unseen, overlooked, or ignored. In the manicured lawn area surrounding the estate there is a sea wall that juts out into the bay, lined with rows of royal palms. These royal palms were also covered in patterns and color, which thanks to my daughter, I had learned to recognize as lichens. But it was not until I zoomed in with my iPhone on Macro settings that I realized that *I* was the one overlooking, ignoring, and not seeing. I began to snap pictures. When I stepped back and looked at the same lichen with the naked eye, I could not see what was now visible in the image on my phone. From these photographs I print enlarged images on acetate. Using a light table, I trace what is there. This allows me to trace without the mental biases that could lead to drawing what I don't see, and not drawing what I do see—a bias that teaching drawing makes you excruciatingly aware of. The quick tracings done with script-like gestures and scribbles further free my mind of potential biases. Through this process, the patterns and structures of these lichens appear to expand exponentially, revealing things that were there in the photographs but hidden from me. Through my tracings, I discover smaller and smaller repetitious forms, each iteration leading to deeper, almost infinite levels of complexity. The more I see, the more I see (Figure 1).

From the beginning I decided I would trace 100 drawings over a calendar year in a series I call *Lichen Poetry*. Approached with only poetic and artistic considerations, these drawings are still recognized by my lichenologist daughter as lichens, sometimes even to the species level. During open studio visits, members of the public have engaged with the *Lichen Poetry*, often leaving with a new appreciation for lichens. These visitors include local scientists, one of whom days later texted, "You have me looking at things I've never

looked at," and included images of lichens from his own backyard. I question who may be the ultimate audience for this work: the science world, the art world, or a broader audience.

[K.S.] During my mother's forays to photograph the lichens on the royal palm trees at the Deering Estate, she noticed something on a concrete bench. This concrete bench was placed at the end of the arm of the boat basin that juts out into the salt water bay. There were lichens growing on the bench, bright orange ones. Because I had recently begun looking at lichens that grow on concrete, particularly sidewalks, my mother sent me a photo of it. After looking at her photograph, I got really excited and asked her to send me more photographs and samples. This appeared to be a lichen that is known to grow on rocks and concrete, but was not previously recorded in south Florida. I am in the process of sequencing the DNA of this lichen to confirm its identification. In pursuing her art and collaborating with me, my mother has potentially found a new locality record for a lichen. This opens up many new questions in my study of lichens on concrete, as well as an ongoing curiosity about the role of salt in fungal ecology.

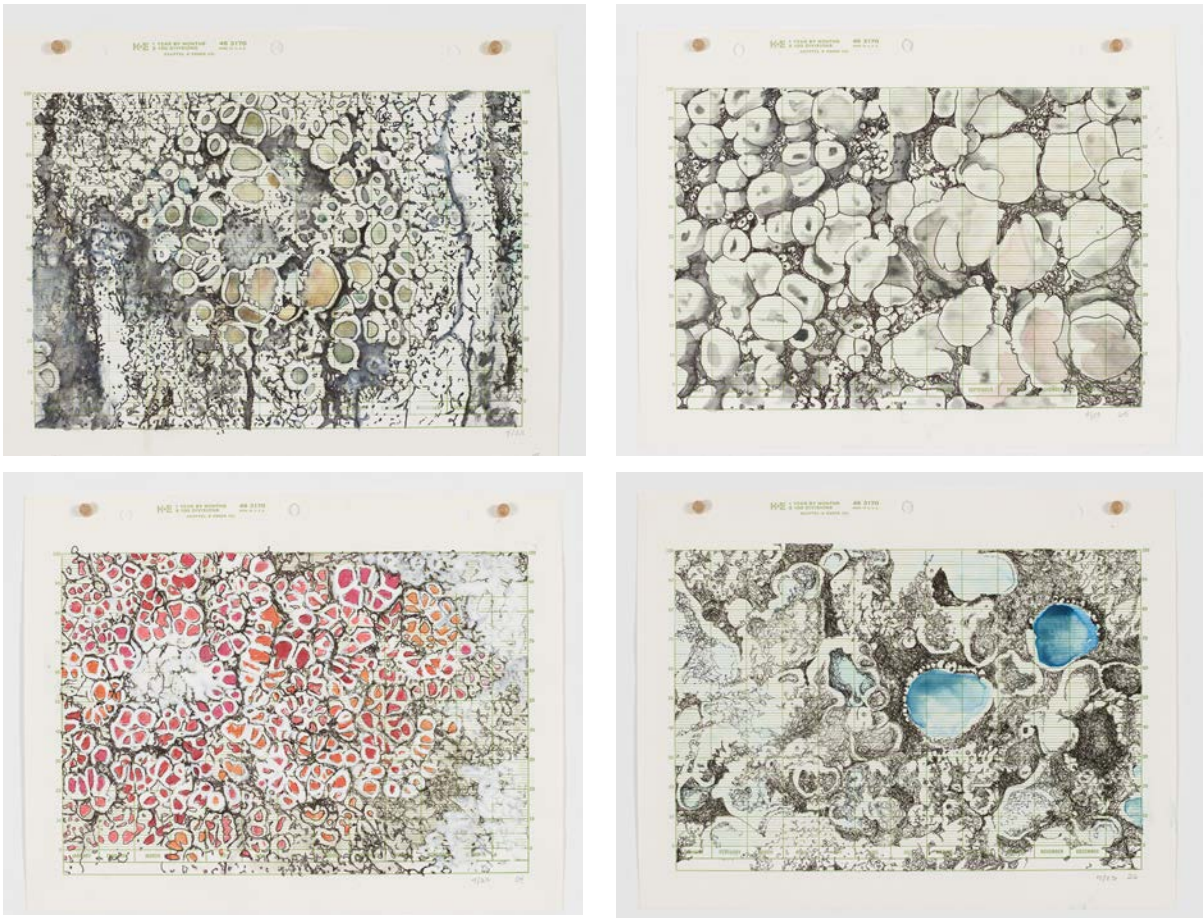

Figure 1. Lichen Poetry *#15, #65, #24, #26. Series of 100 drawings, 2023-2024, 8.5 x 11 inches. Mixed media on 75-year-old student engineer graph paper.*

My mom and I have become lichen influencers, which proves that the most beneficial part of the artist-scientist symbiosis is a broader communication of ideas. In a seminar I recently gave, I talked about lichens that grow on sidewalks and other concrete surfaces. I have since been approached by multiple attendees of the talk who tell me that they have now taken a much closer look at the sidewalks and concrete near their homes, observing lichens there! Both my mom through her art, and I through my science, have inspired others not only in our own fields and each other's fields, but to a larger audience—new ways of seeing and exploring the world.

THE LICHEN LINE

[K.S.] During a research trip to the Andes in Peru, I noticed a phenomenon that I have termed "the lichen line." The lichen line occurs on any substrate or landscape where there is a visible edge between where lichens grow and where they do not grow. In the Peruvian Andes, the alpine glaciers are melting so fast that the lichens cannot colonize the newly exposed rocks fast enough. This has led to a stark difference between the rocks covered in lichens, which appear almost black from a distance, and a kilometer or so of bare rocks, appearing pale or beige, leading up to the glacier. I ran a transect along the ridge and sampled lichen communities leading up to the lichen line, and lichen communities between the lichen line and the receding glacier. The data clearly show that there is a dramatic difference in lichen presence and cover on one side of the lichen line versus the other. When I took photographs of this lichen line, it was difficult to capture the whole landscape in a single shot, and the topography and shadows made the lichen line not appear as stark as it looked in person. Frustrated, I told my mom this story, and shared the photographs with her that I had taken. At that time, my mom was delving into the idea of visuals that describe climate change. Melting glaciers are challenging to depict in a two-dimensional image. From my story and the photographs, my mom was able to create a visual that told both of our stories; glacial recession and the lichen line. I felt that her visual properly captured the starkness of the actual edge of the lichen line, eliciting a more dire and emotional response than my photograph or data may have done (Figure 2).

Figure 2. Suburban Ledgers *(from series) 6.75 × 3.75 inches, 2017-2019. Mixed media on 50-year-old Burdines notebook paper.*

CONCLUSION

Through these stories, we have demonstrated the benefits of the artist-scientist symbiosis through the sharing of insights, expertise, skills, and ways of seeing. Our mother-daughter symbiosis facilitates uncomplicated occupation of the liminal space between the spheres of art and science, whilst remaining rooted in our respective disciplines. Just like in lichens, the value of the particularity of symbiosis is the continuous exchange of that which is beneficial to the other, without the design

of becoming the other. The strength of the artist-scientist symbiosis is in the volleying of questions and hypotheses from two distinctive and often opposite ways of seeing. Both the scientist and the artist benefit from having one foot positioned in proven steps of exploration, and the other foot skipping along in play.

SUPPLEMENTAL INFORMATION

Everglades National Park encompasses 1.5 million acres, protecting a variety of south Florida ecosystems including freshwater sloughs, tropical hammocks, pinelands, cypress domes and prairies, mangrove forests, marine and estuarine, as well as many threatened and endangered plants and animals.

Fairchild Tropical Botanic Garden was established in 1938 by a group of botanists and environmentalists including its namesake, Dr. David Fairchild. It encompasses 83 acres with a focus on tropical and subtropical plants with human uses, and includes a natural history collection, library, and archives. Fairchild Garden supports active research on botanical biodiversity, ecology, and applications.

Deering Estate is a historic landmark in south Florida encompassing 450 acres preserving historic architecture, indigenous histories (including burial sites, middens, shelters, and historic hunting grounds), and native ecosystems. Deering Estate includes the following designations: National Registry of Historic Estates, Miami Dade County Environmentally Endangered Lands, Natural Areas Management, The Cutler Fossil Site, Paleo-Indian Archeological Site, Florida Fish and Wildlife, Department of Environmental Protection Agency, Natural Areas Management.

Attempts at Convergence of Science and Art That Blossomed Amidst Korea's Tragic History

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Abstract

The Japanese colonial era and the Korean War left many scars on the Korean Peninsula, and nationalistic and ideological conflicts resulting from them remain. But even in this turbulent time, Korean scientists made important contributions to biology. Among them were a few people who attempted to use taxonomic illustrations that fused biology and art. Bong-Syup Toh (1904–?) was one of the first Korean botanists and pharmacologists. His wife Chanyoung Jung (1906–1988) was a well-known painter and supported and assisted the botanical endeavors of her husband. The entomologist Pok Sung Cho (1905–1971) was one of the first zoologists in Korea. He was also a skilled scientific illustrator and provided an incredibly detailed and accurate set of butterfly drawings that demonstrated his scientific knowledge. Korea adopted modern taxonomy (Linnean system) relatively late, and therefore the work of the few taxonomic illustrators was exceptional. The purpose of this article is to demonstrate the outstanding nature of and to bring awareness to their contributions, which have been virtually unknown until recently. Understanding their achievements and lives is also the beginning of understanding the history of modern Korean biology.

HISTORICAL BACKGROUND

After 500 years of rule, the Joseon Dynasty on the Korean Peninsula collapsed due to the forced opening of ports (1876) by foreign pressure. Subsequently, the Korean Empire (1897–1910), the Japanese colonial period (1910–1945), and the Korean War (1950–1953) all contributed to a history of suffering on the Korean Peninsula. As the traditional Korean social order began to change, Western culture, including modern science, began

to have more influence. Around the time that Korea opened its harbors, modern taxonomy was first introduced from the West. Although colonial countries had previously developed their own scientific fields, during the period of imperialism they were indoctrinated into or believed that Western-style modern science was essential to an advanced and strong nation. The Linnean taxonomic system also spread around the world after the 18th century in concert with imperialism, whose influence increased in the name of 'modern universality'. During the Japanese colonial era, modern taxonomy was introduced by Japan into Korea to deliberately investigate natural resources in the name of colonial civilization. Additionally, Japanese scholars sought to promote Japan's scientific capabilities to the world by reporting on the biology of the Korean Peninsula. Japan trained Koreans to aid their goals, but limited Koreans' access to high-level science and technology. On the other hand, colonial Koreans thought that their country could become strong, developed, and independent if it had modern science and technology similar to what existed in Japan and Western countries. Some Koreans cooperated with Japanese scientists to learn science and technology, whereas others resisted and pursued independent studies. At that time, the relationship between Japanese and Korean scientists took on various and complex aspects such as cooperation, exchange, oppression, discrimination, consideration, and competition—all having an impact on everyone's life (Kim, 2005). It was very difficult for Koreans to become taxonomists and very few succeeded. This is because Korea's traditional academic and education system, before the opening of ports, was completely different and during the Japanese colonial period, Japan systematically restricted and discriminated against Koreans from receiving modern education. Korean universities were also limited, and it was not until 1926 that the first university was opened and only a very small number of Koreans studied internationally.

Biological illlustration is a field that unites science and art, drawing pictures based on scientific study. Therefore, the situation for Koreans at the time to learn this field was worse than studying biology alone. Moreover, traditional Korean paintings up to that time were very different from biological illustrations. Confucianism dogma was the traditional field of study and the principle of social order in the Joseon Dynasty, and it was also the foundation of art. Although several genres of painting were practiced, most of them were based on the Confucian concept. Some paintings depicted living things realistically, but the objects and composition of these paintings were symbolic or decorative and were not intended to identify species. Since they are Eastern paintings, they did not depict identification keys to distinguish living things and were often patterned or had artificial compositions. Although they depicted living things, they were an effort to contain philosophical meaning. Biological illustrations were naturally introduced to the Korean Peninsula through biology-related books, but a scholarly understanding of this multidisciplinary field was lacking. There was not enough time and manpower to produce illustrations, and there was no educational institution to support the topic. Old records contain illustrations commissioned by painters without scientific knowledge or copies from foreign documents. There were few direct attempts by taxonomists, and professional and high-quality illustrations are extremely rare. The three Koreans introduced here were the starting points of Korean biological taxonomy and biological illustration during these turbulent times, and they were the people who created the framework of current Korean biological taxonomy that still has influence today.

BONG-SYUP TOH AND CHANYOUNG JUNG: A WORK CREATED BY THE LOVE OF A BOTANIST AND A PAINTER

Bong-Syup Toh (also written as Pong-Shyup Toh, Bong-Shyup Toh, and Bong-sup Toh) was one of the few of the colonized who took the elite course during the colonial era. He studied at the University of Tokyo in Japan and became the first Korean professor of the Gyeongseong Pharmacy College, which was the only pharmaceutical education institution in Korea during the Japanese colonial period. After liberation, he served as the Dean of the Private Seoul College of Pharmacy. As a colonized Korean, the process through which he could conduct scientific research was never easy. At that time, there was only one university in Korea, Keijo Imperial University, with no science departments. In addition, Japan restricted science education for Koreans, including limiting the number of Korean students studying science and making it difficult to qualify for entrance exams for Japanese universities. Toh graduated from Japanese schools twice to qualify for the entrance exam to the University of Tokyo. In 1919, there was the March 1st Movement in Korea, a strong national resistance movement against Japanese colonial rule. Afterwards, Japan slightly eased its oppression of Korea and Toh was able to enter university thanks to the added luck of the relaxed education policy at that time. It was very unusual that his outstanding talent and diligence overlapped with his wealthy family and fortunes caused by social upheaval. He is the first botanist of great importance in Korean plant taxonomy for his active plant collection and taxonomic and distributional research. His representative book is 韓國植物圖鑑: 草本部 (*Korean Flora: Second Volume for Herbaceous Plants*, 1956), one of Korea's first botanical illustrations and a compilation of all Korean herbaceous plants. In 1933, he organized 朝鮮博物研究會 (*Joseon Natural History Research Group*) with Korean naturalists and made a considerable effort to educate and disseminate science in colonial Korea. Together with the organization's naturalists, he published 朝鮮植物鄉名集 (*Vernacular Names of Joseon Plants*, 1937), a list of plant names with Korean names. He also published or participated in several other books and academic papers (Lee, 2012). He was abducted by North Korea during the Korean War and never saw his family again.

Chanyoung Jung, Toh's wife, was a pioneer, becoming an established painter during a time when it was rare for a Korean woman to do so. She won several awards at 朝鮮美術展覽會 (*Joseon Art Exhibition*, an art contest held during the Japanese colonial period) and painted lyrical works with detailed depictions of natural objects. Her representative works include paintings of birds such as egrets, chickens, and peacocks, and paintings of flowers such as water lilies, peonies, irises, and chrysanthemums, which are traditional Eastern paintings. She developed the field of color painting within the context of mainstream ink-and-wash landscape painting and pursued the formative beauty of living things. In the late 1930s, she gave up painting because her second son died of illness and her eyesight deteriorated, working instead as a middle- and high-school art teacher. Her achievements were mostly forgotten, especially the taxonomic illustrations that she did for her husband's botanical research. After their daughter Toh Chung-ae published books that depicted their achievements in 2001 and 2003, their collaborations received recognition by the Korean botanical and art academia and were displayed to the public. Representatively, Jung drew all 64 plant illustrations in Toh's co-authored book, 朝鮮植物圖說: 有毒植物 編 (*Taxic Plants in Korea*, 1948). The illustrations are black-and-white line drawings, like those in current botanical illustrations or papers, and include partial diagrams of botanically important roots, fruits, and flowers. She also painted botanical

Figure 1. *(Left) Bong-Syup Toh and Chanyoung Jung. © Toh Chung-ae, Seoul, Korea. (Right) Illustrations for plant taxonomy by Chanyoung Jung were known to the public through an exhibition Rediscovery of Korean Modern Artist 1: When Brushes Are Abandoned at the National Museum of Modern and Contemporary Art at Deoksugung Palace in 2019.*

drawings in her color painting style, which were also made into large hanging scrolls for the education of students. Jung's plant illustrations are unique in that they express Toh's botanical knowledge while incorporating her own painting style at the time. She preserved the manuscript of Toh's illustrated plants of 韓國植物圖鑑: 草本部 (*Korean Flora: Second Volume for Herbaceous Plants*, 1956) during the Korean War, making its publication possible after the war (Bae, 2019) (Figure 1).

POK SUNG CHO: A COMBINATION OF OUTSTANDING ARTISTIC AND SCIENTIFIC TALENTS

Pok Sung Cho had been interested in animals since his youth. He was educated by Doi Hironobu (土居寬暢), a natural history teacher who recognized his talent when he was at 平壤高等普通學校 (currently a middle and high school established as part of the Japanese colonial education policy in Pyongyang, four-year school). After graduation, he attempted to study entomology at a Japanese university, but he ran into policies and institutional problems that discouraged higher education for Koreans during the colonial period, and he eventually became an elementary school teacher. Professor Mori Tamezo (森爲三) of Keijo Imperial University, who came to lecture at the elementary school where Pok Sung Cho works, recognized Pok Sung's insect specimens and extensive morphological knowledge and helped him conduct entomological research. After working as an elementary school teacher for six years, Cho became an assistant at Keijo Imperial University and began research in earnest. He became an entomologist because of the mentoring and support of two Japanese scholars who recognized his talent. At that time, cases like Cho's were very rare and fortunate. He was able to conduct his studies across the entire Korean Peninsula as well as Taiwan, China, and Mongolia with the support of his Japanese teacher. After liberation, he served as the director of the National Science Museum and professor at Korea University and Sungkyunkwan University. Through many field studies, he collected, classified, and reported various types of insects, including butterflies, moths, beetles, and

dragonflies. He studied the ecology and habitat of insects and organized the names of insects and entomological terms. He also conducted research on animals other than insects and published the first biology and zoology textbooks in Korean. He was the first Korean to publish an entomology paper 鬱陵島産鱗翅目 (*Lepidoptera from Ulleungdo Island*) in 1929 and published 83 papers throughout his life. Beginning with 原色朝鮮の蝶類 (*Colored Butterflies from Korea,* 1934), he also published 22 books, including university textbooks, encyclopedias of insects, and science books for the public. In these works, he was able to distinguish himself and prove his talent to Japanese scholars via his artistry. All the butterfly paintings in 原色朝鮮の蝶類 were drawn by him, and the paintings in his papers and books are presumed to be his (Kim, 2008). Cho's original butterfly illustrations were very small because they were drawn in the size of actual butterflies, which is different from the current general style of enlarged illustrations so that the shapes of small insects can be clearly seen. However, even at their small sizes, he produced detailed and scientific drawings sufficient to identify the species with excellent drawing skills and a wealth of morphological knowledge. He also wrote books for children and teenagers, such as 곤충이야기 (*Story of Insects*, 1948) and 곤충기 (*About Insects*, 1948), which confirms his passion for education and his aspect as a creator. Text and illustrations for books and papers for the public are different from those for academic reporting. In particular, he made books for children and teenagers easy to understand and interesting. He personified the characteristics of insects, chose topics that would interest readers, and wrote terminology to suit the reader's level. He attached illustrations showing the ecological characteristics and anatomical structure of insects (Jin, 2019) (Figure 2).

Figure 2. *(Left) Pok Sung Cho* © 관정장학위원회. *(Right) Original illustration of butterflies drawn by Pok Sung Cho.*

REBORN AS A PIONEER THROUGH GENIUS IN A TRAGIC SITUATION

As modern biology was introduced late in Korea, it was very urgent to investigate and organize living things throughout Korea. The research materials of Toh and Cho are the foundation of Korean biology, and later scholars have added to or modified them based on their research. They gave Korean names to native Korean organisms and produced educational materials in Korean to train younger generations. In Europe, where modern biology began early, many living things were investigated and drawn in the 17th and 18th centuries. However, in Korea, which only accepted modern biology in the 1900s, the current level of biology was reached without that process. Photographs were used rather than drawings, and there was a rush to keep up with the flow of the world by embracing new experimental technologies. During the turbulent times, a lot of data were lost, and much remains buried because of widespread ideological conflict. The multidisciplinary creative art that these three attempted is a significant discovery in Korea, where it has only recently begun to be widely recognized as an independent field. Their pioneering results were judged to be of value as an auxiliary necessity in biology, but they need to be

newly illuminated in the arts and multidisciplinary fields. Jung's paintings demonstrate her unique style that combines oriental painting and scientific illustration. Cho can be considered the first Korean biologist to draw pictures at the level of a professional scientific illustrator. Their illustrations are an important asset in Korean biology, but they are also an important asset in art and multidisciplinary fields. The efforts of these pioneers without interdisciplinary training need to be studied along with those of similar pioneers in other countries.

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How Scientific Illustration Impacts Presentation and Understanding of Plant Adaptations at Multiple Scales

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Abstract

Scientific illustration is an integral part of how scientists communicate work to colleagues, students, and the public. Historically, the connection between biology and art was widely recognized, because naturalists had to make drawings to document their observations in the field. However, despite its continued importance, modern scientists generally receive little to no formal training in effective visual communication. On the other hand, artists, even those who are very well equipped to produce accurate and attractive representations of plants, may not appreciate all of the subtle or even microscopic features that are important to scientists.

Here, we discuss the interplay between art and science using the example of a carnivorous plant, *Drosera capensis*. We present strategies for promoting effective communication between artists and scientists, with examples of art illustrating important features at different scales. We also discuss how artists and scientists can collaborate to engage the public and disseminate results in an accessible manner.

Keywords

botanical drawing, carnivorous plant, chemically specific imaging, in situ chemical analysis, metabolites, protein structures, scientific communication

INTRODUCTION

In scientific articles, illustrations and graphics draw attention to particular features, simplify complex systems, and reify abstract concepts. High-quality visual elements can greatly enhance the readability of scientific work, potentially drawing students and colleagues to a study species and widening scientific circles. Further, effective scientific communication can engage the public, enabling scientists to achieve goals such as recruiting for community science projects, promoting conservation efforts, or simply sharing the joy of discovery and the beauty of nature. Even though high-quality visualizations are central to effective communication, very few scientists are trained to produce them. Further, many scientists do not know how to commission art on a practical level, and connections between scientists and artists may be difficult to forge because of the lack of overlap between these communities.

Here we discuss some strategies for addressing these issues, using the example of the carnivorous plant *Drosera capensis* L. (Slack, 1979). *Drosera capensis*, a native of the Cape region of South Africa, grows in wet environments with poor soil. Its long, strap-like leaves are covered with glandular trichomes, each of which is tipped in a drop of sticky mucilage. Once an insect is trapped, trichomes adjacent to the contact area curl to cover and further trap the insect. In cases where the insect is larger and continues to struggle to escape, the leaf blade itself curls around the prey, further immobilizing it and maximizing surface area for digestion. The digestive process is fascinating from a molecular perspective; unlike in animals, plant digestion takes place in the open, under ambient environmental conditions, and in competition with bacteria and fungi that cannot only steal the nutrients from the prey, but potentially infect the plant, causing disease. The plant manages these difficulties using biochemistry. When stimulated by prey acquisition via the jasmonic acid pathway, the leaf secretes hydrolytic enzymes that break down insect tissue, as well as antimicrobial peptides that protect against infection. These processes are mediated by a host of small-molecule signals. Thus, *D. capensis* presents a challenging variety of adaptations to illustrate, spanning a range of length scales from the macroscopic to the molecular.

CROSS-POLLINATION

The first obstacle to communication between scientists and artists is that they often simply do not know each other. Academic communities are often fragmented or siloed, and making trans-disciplinary connections is difficult. Further, field-specific norms for how original work is presented and credited can make it difficult for academics in different fields to collaborate. Initiatives such as this special issue of the *Plant Science Bulletin* provide opportunities for joint work, but it is still necessary for collaborators to find each other. We have found in-person or online hobby groups useful for this purpose: S.D.-B. and R.W.M. first met in an online group devoted to growing African violets; we then worked together on a series of articles published in *Chatter,* the newsletter of the African Violet Society of Canada. Hobby groups of this type are excellent for introducing people with very different backgrounds, but with a common interest in plants. They attract a mix of hobbyists, practitioners (e.g., professional horticulturists and landscapers), and other members of the public. We do not endorse any specific social media sites here because their popularity waxes and wanes, but online groups are often very active and can have diverse members from all over the planet.

Another model for successful interaction is one where scientists commission artists to produce compelling visualizations for their publications and presentations. Informal discussions with other scientists (by R.W.M.) have revealed that many do not know how to find an artist to work with, believe the costs to be prohibitive, and/or find the process of commissioning custom art intimidating. Although hiring an artist as a full-time member of the team is indeed beyond the budget of most research labs, many offer one-time commissions at affordable prices. Depending on the agency, these expenses can sometimes be covered by the communications budget of a grant, or unrestricted funds can be used. Artists can be found on online social networks, where those who are open to performing work for hire will generally indicate this with a "commissions open" tag on their profiles. Websites designed for creators to find patrons (e.g., Patreon, Etsy, or guru) offer another way to hire artists for specific projects. Producing artwork is time-consuming and may require multiple rounds of editing; therefore, it is important to commission the drawings as early in the writing process as possible in order to minimize the time to submission.

After finding an artist whose style fits the desired work, the next step is to inquire about price. It is important to be as specific as possible about the subject of the piece, the required size, any particular features that should be emphasized, and what it will be used for. The latter question

is critical, since many artists only allow certain types of usage or charge different fees for different types of licensing. For example, a design that will be used in a scientific paper may have a different price than one that will be used as a logo for a commercial website. It is best to discuss all potential use cases up front to avoid misunderstandings. For scientific papers and presentations where the artist is not a co-author, the best practice is to acknowledge them for creating specific figures or parts of figures in the acknowledgments.

DRAWING ON THE HERITAGE OF BOTANICAL ILLUSTRATION

Before the advent of high-quality photo and video, botanical illustration was essential for sharing knowledge about the discovery, basic morphology, and ecological context of new plant species. Most students did not have the opportunity to travel to see their study species and had to make do with dried herbarium specimens. Detailed drawings helped fill the gaps between the preserved specimens and the living plant. Although humans have been drawing plants since before recorded history, botanical illustration, along with preserving specimens in herbaria, became more systematized in the 18th century, particularly after Carl Linnaeus introduced his classification system, the Systema Naturae (Thiers, 2020; Blunt, 2021).

Because drawing was considered a suitable occupation for young women in a time when their options were otherwise limited, this is an area where women could participate in science before they were allowed to do so in other ways. For example, Elizabeth Blackwell, better known for her status as the first female physician in the U.S., published an illustrated book of medicinal plants in order to finance her husband's release from debtors' prison (McDowell, 2023).

IMAGING ACROSS MULTIPLE LENGTH SCALES

One of the biggest challenges in imaging plant samples and conveying the information we learn is that the key features occur on very different size scales. Just as the earliest botanists did, we need to show pictures of the whole plant, preferably in the context of its habitat, but also close-ups of individual organs such as leaves and flowers. We need systematic protocols for showing all of these things in the diagrams. In addition to the accuracy of the representation, selecting and editing appropriate features and characteristics play an important role in drawing the reader in, generating enthusiasm for the study species and supporting conservation efforts.

Features of interest are sometimes difficult to notice in even a high-quality photo without visual cues to draw attention to them. For example, *D. capensis* is a relatively large, showy plant with long, dramatic flower scapes (Figure 1), but many of its important features (e.g., the trichomes bearing sticky mucilage), are very small. Further, a typical plant will not display all of the significant characteristics, such as blooming, seedpod formation, or trapping and digesting insects, all at the same time; therefore, creating an illustration that showcases these characteristics at the same scale is extremely useful for providing a holistic overview of *D. capensis*. Figure 2 shows a botanical illustration of *D. capensis* created with Adobe Illustrator vector-based digital illustration software using live plants and pictures for reference. Although this diagram is traditional in most respects, it also includes structures of proteins that were discovered from the *D. capensis* genome (Butts, 2016) and are thought to be important during feeding. Vector-based graphics use shapes, curves, and lines that do not lose resolution when enlarged. In the past, S.D.-B. has used traditional media (paper, graphite pencils, and watercolor) to draw botanical illustrations with the final illustration scanned and stored as a raster image, comprising individually colored

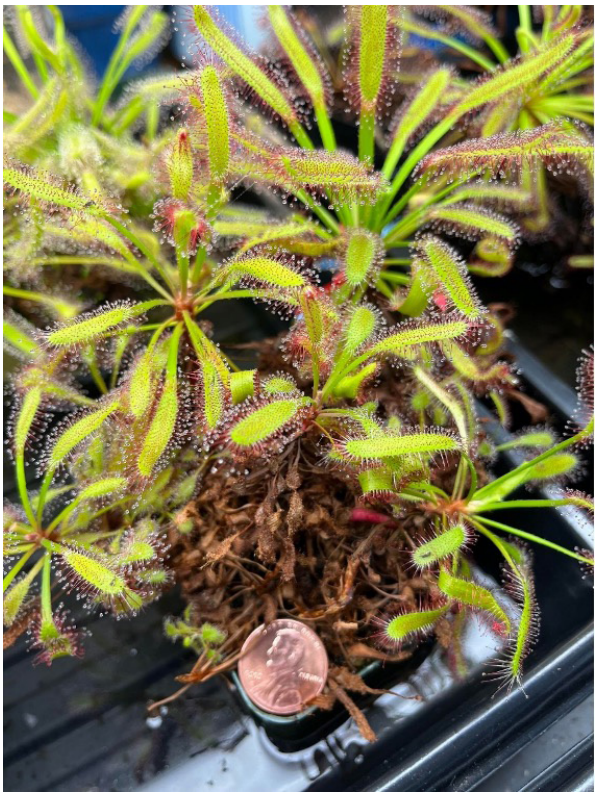

Figure 1. *Photo of several* Drosera capensis *plants in cultivation with a U.S. penny for scale.*

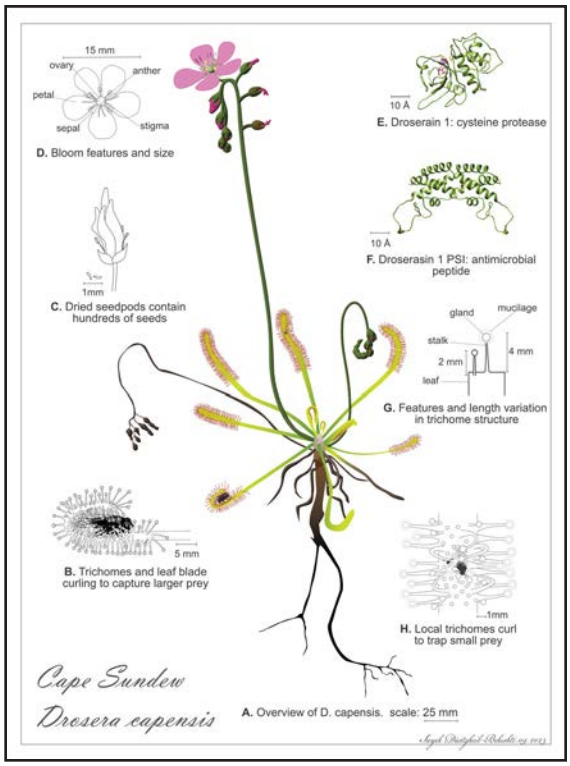

Figure 2. *Traditional botanical drawing with additional features of varying length scales, including proteins produced by the plant.*

pixels that limit the final resolution and possible edits. The highly detailed and repetitive features of *D. capensis* as well as the need for constant communication with the scientists during the generation of the imaging process diagrams led to the selection of the non-traditional vector-based illustration tool for this collaboration. Figure 3 illustrates how vector-based software allows for enlarged views of details without the loss of resolution, as well as enabling details such as colors to be changed easily.

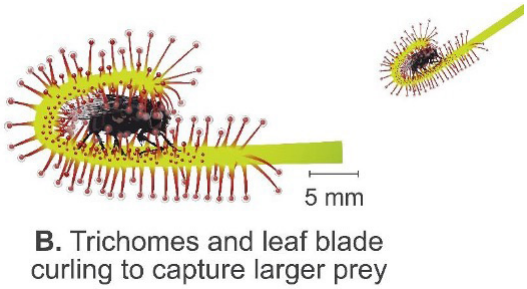

Figure 3. *Detail of Figure 2B, with a leaf wrapped around a fly. This expanded image shows how the vector-based software allows for enlarged views of details without the loss of resolution and enables adjustment of the colors for different purposes.*

VISUALIZING THE INVISIBLE

The length scale problem is even more pronounced when we focus on chemical adaptations. Plants are talented and prolific biochemists: they have produced many of our medications, from the earliest (e.g., salicylates from willow bark) to the most sophisticated (e.g., taxol) (Verpoorte, 1998; Lautié, 2020). These molecules have fascinating structures and play important roles in our society, yet our representation systems for displaying them are complex and difficult for non-experts to appreciate. A study of cultural overlap among different fields has found that molecular biology is highly intellectually isolated from other disciplines because of the barriers presented by its specialized terminology (Vilhena, 2014). Carefully chosen visualizations can help bridge this gap, from highlighting important parts of molecules to using visual analogies to explain molecular function.

To explore the challenges of communication about complex scientific concepts, we chose to illustrate the example of plant tissue imaging conducted using matrix-assisted laser desorption/ionization mass-spectrometry imaging (MALDI-MSI), which was recently applied to *D. capensis* (Long, 2023). This chemical imaging method maps the spatial distribution of molecules on the leaf surface. Figure 4 shows the process of generating a scientifically accurate schematic of the experiment. The creation of this diagram required extensive discussion. First, R.W.M. provided a general description of how the experiment works, with molecules being extracted from the leaf surface and sorted by mass. S.D.-B. then drew the diagram in Figure 4 (top). The scientific team (R.W.M., Z.G.L., and G.R.T.) then discussed the image and concluded that it did not accurately represent the experiment, as molecule collection and separation happen in discrete steps (Figure 4, center). Finally, S.D.-B. incorporated this feedback to create the final image in Figure 4, bottom. The fact that the scientific and artistic collaborators are not in the same physical location added an additional challenge; this was addressed using a combination of videoconferencing, photos of the experimental apparatus, and sketches of the desired image.

CONCLUSION

Artwork has always been central to the practice and dissemination of botany. Accurate and evocative drawings not only enable scientists to show and highlight important plant features, but also generate interest in and respect for their study species. Collaborations between scientists and artists can improve the quality of scientific communication while also forging new connections across disciplinary boundaries.

Author Contributions

R.W.M. designed the study. R.W.M. and S.D.-B. wrote the first draft of the manuscript. S.D.-B. created all vector graphics. Z.G.L. provided small molecule data, took the photo in Figure 1, and contributed to image design. G.R.T. provided protein sequence data and contributed to image design. All authors edited the manuscript.

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Conflict of interest

The authors declare no competing interests.

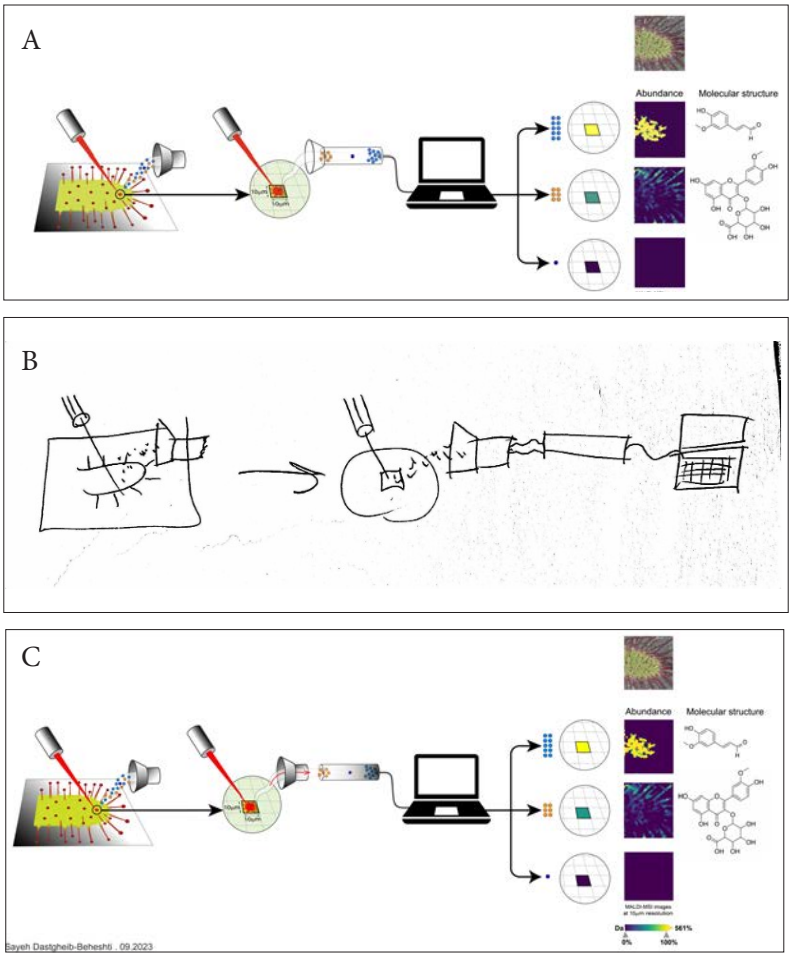

Figure 4. *Illustration demonstrating the process of making a diagram showing how chemically specific imaging is performed to map the spatial locations of small molecules on a leaf. This diagram required edits for accuracy. (A) Initial diagram of the experiment drawn by S.D.-B. based on a description from R.W.M. (B) Sketch by Z.G.L. showing how introducing the molecules into the instrument happens in a separate step from sorting them by size. (C) Final schematic showing the key experimental steps.*

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An Abstract Scientist: Embracing Art as a Tool for Science Education

Patricia Leyva

Art is essential for the spread of scientific knowledge. In botany, for instance, anatomical illustrations of plants are imperative to understanding the physiology, morphology, and evolution of diverse plant species. Before the invention of cameras and the advanced imaging we have today, botanists relied on the precise illustrations of plants. Sixteenth-century German herbalist Leonhart Fuchs states in his publication, *De historia stirplum*, "Those which are explained and depicted to the eyes on panels or paper adhere to the mind more deeply than those described by bare words" (Kusukawa, 1997). Fuchs's work was highly influential and set a high standard for botanical illustrations. Understandably, scientific illustrations must be accurate and meticulous. For instance, illustrations in herbal books, like that of Fuchs, were used to correctly identify medicinal plants. In the 16th century the accurate identification of medicinal plants was a matter of life and death. However, because of the advanced imaging of today, scientific illustrations can now serve a different purpose.

I believe that art can be used as an outlet to process and express complex science ideas. My career goal is to be an educator; however, as a person with attention deficit disorder (ADD), it is challenging for me to process and communicate complex ideas using words. Through art, I use my imagination and creativity to overcome this. As both a scientist and an artist, I enjoy creating drawings that defy the laws of nature. For instance, my ideas for drawings of herbs are far from accurate. I envision turmeric as a sunset whose rays of light penetrate the soil forming a glowing web. The sunset, for me, represents the color of turmeric and the penetrating rays of light into the soil remind me of the benefits of turmeric for the skin and as an antioxidant. As an undergraduate taking biochemistry, I would study the ten steps of glycolysis by visualizing a candy bar going through a conveyor belt and being broken down to its different components.

I am currently working on earning a PhD in plant biology, and my work focuses on the transport of organic acids in plants to aid in the resistance to metal toxicity. My drawing *The Gateway into the Cell* (Figure 1) is of a cell membrane transporter

Figure 1. *Leyva, Patricia.* The gateway into the cell. *2023 Ink drawing. "Drawing of a plant cell with a membrane transporter resembling a gate for which selected substrates pass through the lipid bilayer into the cell."*

as a massive gate made of unique blocks that affect what passes in and out of the cell. I instruct a botany laboratory course for undergraduates, and I advise them to study by thinking of creative connections among the course material. Also, I want to communicate the purpose of my research in a meaningful and unique way to my students. In my drawings, I see the beauty of a biological process, which validates my work's meaning. Biology is an art, and that captivates me. I want people to be intrigued by an eccentric drawing of cellular transport and curious about how the process works and why it is essential. My goal as an educator, scientist, and artist is to sow a creative seed in the scientific minds of my students.

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Three Plants, Three Practices: Botanical Allies and the Creative Process

Peri Lee Pipkin

I'm a non-traditional scientist. I didn't get my start as a fresh-faced teenager with a science degree; I meandered and took back alleys and talked to plants, arriving at the start of my botany Master's degree with silver streaks visible at my temples. I have neurodivergencies that prevented me from walking a straight line, and a queerness that never let me belong there anyway. These experiences allowed me to merge creative practices with the world of plants and opened the doors for me to their realm. Over the course of three plants, I'll discuss the ways three different art and craft practices enabled me to develop bonds with plants and the importance these non-quantifiable connections have for our mental health, our sense of belonging, and our connection to the plants.

I. DRAWING: SAGEBRUSH

The great silence of Oregon's high desert caught me off guard. A hushed expansiveness only interrupted by a snapping twig, the footsteps of the group, the occasional grove of flustered aspen. I had never seen an openness like this before. I'd arrived only days earlier from a city crawling with vines and air thick with the aroma of fried food and exhaust, with movement a constant, and I was now waist-deep in sagebrush. I'd never carried a hiking pack before, and I'd never been around so many loud and confident Americans, but I was thirsty to join the pack. Very rapidly, it was made clear I wasn't going to make the cut. I talked too fast or didn't talk at all, I wasn't from there, wasn't interested in boys, was too different. The list of lacking went on. I'd spent most of my life as an outsider, a foreigner, and here I was in the place that was advertised as this land that accepted all, and I didn't belong here either.

As the trip went on, the nights in the tent began to feel like eternities. At dusk, we were supposed to be reflecting and journaling, but dwelling on the experiences of the day felt suffocating. I'd stopped sitting near the group, sore from their slicing comments and instead would slink off into the sagebrush and lay low. At dusk, a habit began to settle in: pick the slender flowering tops of the sagebrush, only the softest. Climb into the hand-me-down sleeping bag. One bundle of leaves and flowers under one armpit, another under the other, for freshness. One small bundle to hold and to smell. Roll onto stomach, open notebook.

Mechanical pencil to scrappy notebook paper. From there, small lobed leaves sprouted between notes and half-finished thoughts. Detail, detail, detail. The curve of the leaf tips, the tiny flowers, the texture of bark, small things that made the jeers of the group anchor under my skin less deeply. It made the human world, a world proving to me more and more unforgiving with its boundaries of acceptance, fall out of view. In a way, sitting with sagebrush and moving my pencil across the pages was where I first learned to meditate. That plant spoke to my teenage loneliness, its continued presence becoming a friend. It was in that tent that I learned that botanical drawing is an experiment in intimacy with the plant world. It forces you to notice the small details, and it forces you to be present with the plant. It elevates your experience with a plant from just something of interest growing in the landscape to an entity. Maybe this is just the first step in seeing the plant world outside of the linear boxes so many of us have drawn and fit ourselves into.

II. PIGMENTS: POKEWEED

Keep moving. Throughout my early 20s, those words felt like excellent advice. Hitch a ride, try a city out for a while, hop a train, meet some new people, admire some weeds. I felt as if I stopped moving, my blood would stop flowing. To be honest, I don't know how many houses I lived in during this time, or if some of those structures even counted as houses. All I knew was that there wasn't really anywhere in particular I belonged to, and there wasn't anywhere in particular I was headed. In Oakland, I moved into a dilapidated punk house and impulsively enrolled in a community college course called "Alpine Labs." Before I knew it, I was in a well-loved rental van headed to the Eastern Sierra in a group of Bay Area community college students. I had slept outside many times since my last backpacking trip as a teenager but hadn't officially been tent camping since then. Memories of that trip flooded in, and I felt a heightened anxiety and impulse to isolate myself and turn to the plants. However, I quickly realized that aspiring botanists are equally as interested in focusing on the plants, so I was in good company. Throughout that week, I got the opportunity to slow down and sit with the plants and some of the people that love them.

Returning to the city, I felt a less urgent sense to go. I thought about the plants I'd walked right past, without the opportunity to get to know them. I thought about all the places I'd fled based on narratives I'd constructed for myself. That's when I noticed it: glowing magenta berries hanging in neat clusters. The lanky plant reached through the chain link fence of an abandoned lot filled with the ruins of smashed electronics, dangling their fruits across my path. I stopped and inspected the berries. "Poison!" My roommates warned. "But a nice ink!" Another added. Intrigued, I clipped some clusters and brought them home to experiment. After smashing them in a mortar and pestle, I added vinegar and salt—the advised binders and preservatives. From my paintbrush flowed a color so saturated and unrealistically lush that I felt like I had unlocked a secret. What colors were hiding in the plants? What would the plants show me if I slowed down long enough to listen to them? Did they tell their stories in colors and aromas rather than through sounds and words? By slowing down and taking the time to work with the plants, the plants can reveal their hidden stories through their language of pigments. If such vibrancy can find its way up through a trash-filled empty lot, how can I let my own vibrancy rise through my own personal challenges? Maybe rooting somewhere long enough to learn the colors of the landscape can help us ground when we feel groundless.

III. DYEING: CREOSOTE

Of all things to finally tie me down, it was the Mojave Desert and the smell of creosote during the rain. From my window in the Mojave, my world was composed of the scattered shrubs, ephemeral desert dandelions, and cactus wrens calling from their fortresses of cholla cacti. I didn't want to be anywhere where the grounding, calming aroma creosote wasn't. In a moment of what was either extreme clarity or the beginning of a mental break, I realized if I just soaked all my clothes in creosote, that aroma could follow me throughout the day. From this evolved a practice of natural dyeing. Sitting with the plants, simmering, soaking, fermenting, experimenting. Mordant? No mordant? Less plant material? More time? Once an energetic herbalist told me that creosote essence shines light into our darkest corners, and as I sat over the steaming bath of leaves, I thought about the dark corners of myself that could stand to be illuminated and sun-baked.

There is no scientific backing for her statement or for my experience, but through this time experimenting with the plant in an intuitive way, I felt a new boldness and acceptance when considering my anxieties and alienation. I suppose creosote is colloquially called "The Governess" for more than one reason. Wearing the sun-hued fabric dyed with the creosote made me feel like I was walking with the strength of the high winds of the desert and energy of the flash floods. I felt like I could walk with the plants that spoke of unbearable heat and untempered resilience. This outfit of botanical armor I'd created through dyebaths and my friend the creosote bush taught me that the plants are here for us, they are part of us. They are here despite us. The plants disrupt the neat boxes society constructs for both them and us. Plants are energetic, sensual, magnetic, mysterious. They encourage us to explore past what we know to be true and don't always offer us reasons why we should. As plant scientists, we define exploration as systematic testing, experimentation, and observation—but what about the non-quantifiable experiences with plants? How can we measure the way a vegetal fragrance or certain shade of ochre makes us feel? Is our unspoken sense of belonging among the plants something to hide from our scientific peers? Is a relationship with the plant off-limits? Craft and art can bridge the gap. The title "scientist" doesn't mean the paintbrush is a forbidden tool or that bending a willow branch into a basket is a baseless act. Ultimately, there is no singular creative practice that forges a connection with the plant world; it's simply the presence of a creative practice that admits us passage between worlds. Cultivating these creative practices and being open to where these practices lead us is critical to understanding the interwovenness of being a human on this planet, and illuminating this interwovenness is critical in working to conserve a biodiverse future.

Plant Motifs Depicted in Kutch Embroideries and Its Integration in Sci-Art Collaborative Educational Models in the Indian Educational System

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Abstract

India holds evidences of the oldest civilizations; the country has an abundance of the traditional knowledge and intangible cultural knowledge to take account of. In present times of rapid technological advancements and urbanization, there are chances that if not documented and integrated in right directions, we may lose the treasure of intangible cultural knowledge and traditional knowledge of the country. Thus, in the present study the attempt has been made to document and conduct visual analysis of plant motifs depicted in Kutch embroideries; the outcome of the analysis is further used to suggest the path to integrate such important knowledge and skills into formal education system at all levels considering the national education policy.

Keywords

Craft, intangible cultural heritage, national education policy, traditional knowledge

> "Knowledge and practices concerning nature and the universe include knowledge, know-how, skills, practices and representations developed by communities by interacting with the natural environment" (UNESCO, 2023).

This kind of thought process is expressed through various mediums such as language, oral traditions, and memories. A community's relationship with nature also influences its values and beliefs, which may in turn be the source of its social and cultural practices and rituals. Included in this category of knowledge and practice is the wider spectrum of traditional knowledge, including of local flora and fauna (UNESCO, 2023). Since evolution, plants and humans have long maintained a symbiotic, yet complex, relationship (Pandey, 2020). Not only are plants a source of oxygen, sustaining human life, but also as a source of food, medicine (Bamin and Gajurel, 2015), and other useful resources such as a source of dye for cloth and body decorations with flowers (Romph, 2023). Humans have interwoven plants into their culture and rituals,

especially in India, where there is a tradition to worship nature and plants (Swaminathan, 2015; Nath and Mukherjee, 2015). Many parts of plants, whether leaf, stem, roots, fruits, or flowers, are an important part of several Indian customs and rituals (Bamin and Gajurel, 2015; Kumar and Kumar, 2005). Studying the relationship between human and plant, as well as humans' influence on and influence by the plant world is an important branch of research known as "ethnobotany," where "ethno" refers to the people, culture, a culture's collective body of beliefs, aesthetic, language, knowledge, and practice, and "botany" refers to the study of plants (Humphrey, 2022).

Indigenous communities, apart from ritualistic inclusion, celebrate and value nature's treasure, such as plants and fauna, by paying respect to the natural world in various ways. For instance, plants' forms and shapes are depicted in many art and craft forms in stylized renditions by these communities. Various plant forms are widely seen in forms such as cave paintings, metal and stone carvings, and printed textiles (Prajapati and Tiwari, 2021). These depictions have been a way to pass on knowledge of useful and culturally important plants to the next generations.

With the aim to document the knowledge and creative depiction of plant knowledge of artisans in these communities, efforts have been made to study the various parts of plant-inspired motifs depicted in embroidery, as an integral part of the cultural and social identity of Kutch communities (Sabnani and Frater, 2012). For these communities, the embroidery, though simple, can be symbolically interpreted as a medium to express emotional bonding with children, a welcoming gesture to daughter-in-law and son-in-law, or as a token of infinite affection for grandchildren. The artists creating this embroidery can also be understood and appreciated much beyond their fine-motor skills—their craft is a demonstration of their fabulous representational capabilities, which turn botanical forms into a piece of art—which from a memory-stored image transforms into stylized renditions through these artisans' imagination and creativity. Above all, artists' work may be interpreted as their love toward nature, which is translated into embroidery and then transformed into, for example, a reflection of a mother's love to her children and family members. Based on this visualization, representation, imaginative, creative, and reflective peripheries, the second part of this article attempts to describe and discuss the relationship between art and science, the application of such handicraft techniques to teach and document practices and species in the areas of science and technology, and its implications for incorporation into education pedagogies.

ABOUT COMMUNITIES OF KUTCH

Kutch is known as a plethora of crafts, including embroideries. Table 1 explains the details of the communities who practice embroidery. These communities migrated from various Middle Eastern regions and from other regions of India in the distant past to settle in Kutch. They continued practicing this beautiful craft even after migration. Many communities also exchanged embroidery styles and cultures either during migration or cohabitation.

Methods and Tools

Secondary research was conducted by referring to various online and offline sources. Interviews coupled with observation and photographic documentation were used to collect data regarding plant motifs embroidered by various communities through purposive sampling technique for conducting primary research. Visual analysis was conducted following the principles of art and design to interpret or correlate with the source of inspiration or the plant of resemblance. The outcome of the visual analysis has been co-related with the particular area of science and technology

Sr. No.	Community	Region of Migration	Region of Habitats in Kutch
1.	Halayporta	Sindh	Banni
2.	Raysi potra		
3.	Pathan		
4.	Mutwa		Banni, Nakhatrana
5.	Node	Iran	Banni
6	Darbar	Sindh and Rajasthan	Makhatrana, Abdasa, Lakhapat
7.	Meghwar		Banni, Bhuj
8.	Sindhi memon	Sindh	Bhachau, Rapar
9.	Jat	Baluchistan	Banni, Nakhatrana, Lakhpat
12.	Ahir	Mathura	Bhuj, Anjar
15.	Rabari	Jaisalmer via Baluchistan and Afghanistan	Bhuj, Anjar

Table 1. *Kutch Communities' region of migration and current regions of habitats (Pandya and Dholakia, 2013).*

for putting forward the ideas of integrating sci-art in teaching learning models.

Results

The analysis of the data revealed the fact that the communities took inspiration from the various parts of the plants, which were rendered stylistically or metaphorically. Flowers, fruits, vegetables, leaves, and stems served as an inspiration. Figure 1 represents various plant-inspired motifs depicted in distinct styles.

Observations and Interpretations

The majority of the floral motifs that were depicted with white color may indicate the original color of the flower that was a source of inspiration, or may indicate that the actual color of the flower was forgotten, with white used as a standard filling. There is also the chance that, considering the scarcity of dyeing material, colored threads were avoided because of their high cost. However, it is difficult to be convinced that all the communities drew inspiration from the same source, or that the overlap in imagery was a mere reflection of cohabitation and copying the motif and depiction from each other. Another prominent fact that comes across is many of the floral motifs' sources of inspiration were unknown, which may be another reason to depict the flower motifs in white—a conscious decision taken by communities to not misguide the viewer. The stylization of the motif form may have taken place to match with the particular embroidery style, overall look, as well as the stitches used in the particular embroidery; ultimately it would have been resultant of the artisan's creativity and imagination.

Depiction of floral motifs such as *Bhori ful* clearly shows the imagination capabilities of the artisans, where they knew the art of stylizing the motifs according to the space available. The motifs also serve as a sampler to demonstrate creativity; as with the same core form, infinite renditions were observed across the communities.

Visual analysis of all the motifs clearly shows that the artisans possessed explicit and implicit knowledge of elements and principles of design and geometry. Perfect divisions of the available space to create motifs and balanced color palettes were evidence of the same. Certain motifs such as depiction of *Farai, Kharek, Jhad,* or *Aambo* were

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Bhori ful		Flower of the berry tree	Halay porta Node	Representation varied according to the placement and layout
Bhori ful		Flower of the berry tree	Darbar and Meghwar Mutwa	Representation varied according to the placement and layout

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Ful		Not known	Halay potra	nine petal motif -the petals were narrower and longer with sharp curves
Golful		Not known	Halay potra, Raysi potra	Seven petal motif- petals were wide and shorter in length (embroidered with white colour by both the communities - indicates same source of inspiration)
Tre khune valo phul		Not known	Halay potra, Raysi potra	(embroidered with white colour by both the communities - indicates same source of inspiration)
Nade ja gul and Farai		Nade ja gul-not known Farai (seed pod)- a motif inspired from ground nut pod or green gram pod	Halay potra	Geometrical depiction , embroidered in white , linked with Farai

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Butti		Not known	Darbar and Meghwar	Not applicable
		not known		Not applicable
Chakkan		not known	Mutwa	Not applicable
Tre fnagadi wali chakkan ji butti		not known	Mutwa	Not applicable
Gul		not known	Mutwa	Not applicable

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Tadi valo gul		not known	Sindhi memon	A motif with triangular leaf shape petals with mirror placement and in centre floral motif called tevrani flower.
Tevrani Ful		Regional flower grown in sindh		Whole flower depiction with stem Half flower depiction Whole flower depiction
Sinye nu ful				Always embroidered with white, indicating original colour of flower
Limbodi Aanko		Neem tree fruit	Jat	A typical geometrical arraengement of diamond shaped motifs with the centre part embroidered with circular shape indicating fruit
Khil ful		not known		Abstract depiction of flower motif
ful		not known		Geometrical rendition of petals with white colour indicating the original colour of flower

Figure 1A. *Visual and textual details of plant-inspired motifs.*

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Kungri valo gul		Not known	Halay potra, Raysi potra, Pathan	Mirror in center surrounded by zig-zag (known as kungri) line closed with outer circle
Pakke jo ful		Not known	Node	Mirror in center encircled by 15 to 23 petals. Each petal was around one centi- metre long and curved from the top
Aath Khuiye vali butti		Not known	Node	Aath khuiye vali butti,- butah motif with eight corners
Bhuli ji Butti		Nose pin known as Bhooli		Worn by newly wedded bride

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Fuladi		Nose pin called Fuladi (a vernacular term for flower)	Jat	Geometrical division of circle embroidered with four colours
Tari No gul		Not known	Node and Rayasi potra	Abstract form depicted floral motif
Badam tak		*Badam*- motif inspired by almond *Tak* - vernacular name of the mirror	Darbar and Meghwar	Alternate arrangement of mirror in almond inspired motif
Char butti no gul		Not known	Darbar and Meghwar	A composite of four floral motifs in stylistic manner

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Adh Kharek		Halay potra and Raysi potra	Date fruit grown in the parch region (in Sindh and in Kutch)	*Adh kharek* - Half date fruit
Kharek ji Butti		Date fruit	Meghwar	Not applicable
Golaido (as depicted in around 70 year old specimen)		Golaido; as stated by the artisans it was inspired by the leaf of Little gourd (Cossignia Grandis) but on observing the creeper it was found that the shape of Golaido resembled the flower of the creeper	Mutwa	Geometrical rendition of petals with white colour indicating the original colour of flower
Golaido		Same as above	Mutwa	This particular motif was resembled bhori ful depicted by other communities
ful		Not known	Pathan	Not applicable
Jad / Aambo		Mango Tree	Ahir	Abstract depiction by half circles and mirrors

Motif	Photographic representation	Source of inspiration	community	Any other peculiar information
Jad / Aambo		Not known	Rabari	Abstract depiction of trunk, leaf and bushy part of the tree
Keri		Mango fruit	Ahir	Stylized rendition of mango
Ful		Not known	Rabari	Imaginary depiction of flower

Figure 1B. *Visual and textual details of plant-inspired motifs.*

the best example of abstract stylization of the motifs, where the inspirational source has been depicted metaphorically.

SCIENCE-ART COLLABORATION AND ITS INTEGRATION IN EDUCATIONAL MODELS IN INDIAN CONTEXT

Emei Ma has defined sci-art as "any creative expression where the intent of the artist is to convey an observable understanding of the physical universe." Application of art to depict scientific forms is as old as the works of Leonardo de Vinci, who used techniques from both of the fields to develop and understanding of the world (Pappas, 2021). Art is thought of as more related to the processes of 'creativity-imagination-visualization'; similarly, science learners imagine abstract forms and formulas while learning about scientific concepts. Collaboration between the two fields makes the scientific concepts of the world understandable (Powers, 2020). Such concerted collaborative residency models and platforms are already in function across the globe (Beeton, no date; Benko, 2020), where scientists and artists work together to develop science-based artistic 2D and 3D models that can help in improving the understanding and interpretation of both the fields. Taking directions from such examples, it is highly important to integrate India's traditional knowledge system and heritage into the formal education systems of the country, especially now when India is implementing the National Education Policy-2020 with focus on holistic, integrated, enjoyable and engaging learning pedagogies (National Education Policy, 2020). A pilot project can be conceived, keeping in mind these floral embroideries or similar motifs and the artisans of such art forms, which can be incorporated in educational pedagogies at all levels of education starting from early education level to adult education. Art forms, traditional knowledge, or indigenous practices attracting specific age group or demographic populations should be selected to make science and mathematics concepts and theories-related learning more relatable, which will further foster encouragement, motivation, and enthusiasm to study particular subjects. Additionally, such initiatives will encourage the artisans through economic empowerment and will motivate their next generations to continue crafts. Moreover, such models of education will further impact classroom absenteeism positively (National Education Policy, 2020) with increased interest and motivation among learners to attend class with more keenness and concentration.

To quote an example, a color trend workshop was organized by National Institute of Fashion Technology (NIFT) Gandhinagar in 2014 at a national craft fair and summit (Joshi and Chopra, 2014), in which I (author) was a part of the team. The aim of the workshop was to make Indian traditional crafts artisans aware of how design houses plan and execute new designs based on forecasted trends. Tuning with artisans' mindsets and way of thinking, the workshop had put up European forecasted stories transformed into an Indian context and more specifically made so that it would be closely related to the artisans. The workshop also hoped to show them ways to forecast and create their own trend stories. As an extension of this outreach, a rural women's cluster to whom SOACH, a nonprofit that works to impart skills, was also invited to participate. One of the exercises in the workshop was to choose one poster (from a series of posters), comprising a collage of images that contained farms, natural sceneries, local flora/fauna, etc. and pick a palette of colors from the images, in the order of their color dominance. After returning to the village, SOACH asked the women for their learnings and observations. One of the women commented on how many different whites there are in the color white. This was an especially perceptive observation that even most design students miss. Following this response, Ms. Jaai Kakani, founder

of SOACH, asked the cluster to identify all the things white in their village and integrate them in their work, creating a series of hand-embroidered pieces of all things white in the village. Ms. Kakani during an in-person conversation explained that "this had a twofold transformative impact. Firstly it encouraged the women to lead their creative process by observing and seeking inspiration from their environment and experiences rather than repeating old traditional craft identities. It also inspired them to look at and create a whole new vocabulary of design motifs and color palettes. The series was a delightful treasure trove of hand-embroidered whites—from rice and cotton in the fields, to clouds, rain, ducks, garlic, the Jasmin flowers, and more! It was also a big departure from the normative colorful bright vistas of the artisans. Yet, the very urban and contemporary fondness for white looked equally at home in this bucolic rural landscape because it truly was from that environment. Design principles and trends are most often difficult to aesthetically grasp and can look awkward and borrowed even for veterans; but when they emerge from the depth of experience and observation, they can be transformative, both for the creator and the observer."

In higher education, a research-based approach can be adopted, taking motifs depicted in the current study as a reference; a team of embroidery enthusiasts and botany researchers can also undertake research to identify similarities in depicted motifs and the plants grown from the regions of these communities' migration and across the route they have followed to reach India.

CONCLUSION

Stylistically depicted plant-inspired motifs in Kutch embroidery serve the purpose of documentation of plant species and may also serve as a clue to botanical knowledge for future generations, although a gap of uncertainty of sources of inspiration can be bridged by combined research from both fields. For a country like India, which on one hand possesses evidence of ancient cultural and intangible heritage and on the other hand is an emerging technological hub (especially with the implementation of its National Educational Policy), the boundaries between art and science are again merging. Holding multidisciplinary expertise is a dire need during this time. There is no doubt that sci-art for education and sci-art initiatives have a huge scope in the future. It is believed that the suggested examples in the present paper will surely be helpful in implementing sci-art–based teaching learning models in India and around the world.

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Art-Making and Plant Biology as Synergistic Learning Tools: Reflections on a Sci-Art Undergraduate Course About Climate Change

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We are a group of 15 undergraduate students and one assistant professor at Smith College who participated in an experimental, upper-level course, "Understanding Climate Change through Plant Biology and the Arts." Launched in Fall 2022, this botanical sci-art initiative used interdisciplinary ways of knowing to deepen our understanding of climate change by integrating plant biology and art. Students read papers about drought-induced tree mortality, arctic shrubification, CO_2 fertilization, and urban plant ecophysiology. We then engaged with the content by each creating three artistic "processing projects" over the semester, writing a corresponding two-page artist statement related to the scientific content for each, and discussing the projects in class in a workshop format. These projects unified science and artistic expression to create a unique learning environment that facilitated community building and emotional connection to the subject matter.

As we deepened our relationship to plants and climate change, students created songs, digital art pieces, comics, poems, sculptures, posters, chlorophyll prints, and multimedia installations that we then presented as an art show open to the local community. Figure 1 shows a sample of the art pieces made in class, with an accompanying description. (Please explore the other art pieces at this link: https://tinyurl.com/3pkvx9dm.)

The goal of this class was to redefine the way students engage with botanical learning. By exploring their own personal connections to the natural world, students were able to more thoroughly interact with course content and build relationships with nearby communities. When asked about their experience with the class, Virginia Griswold, wrote that "creating art allowed [her] to unravel complex physiological and ecological

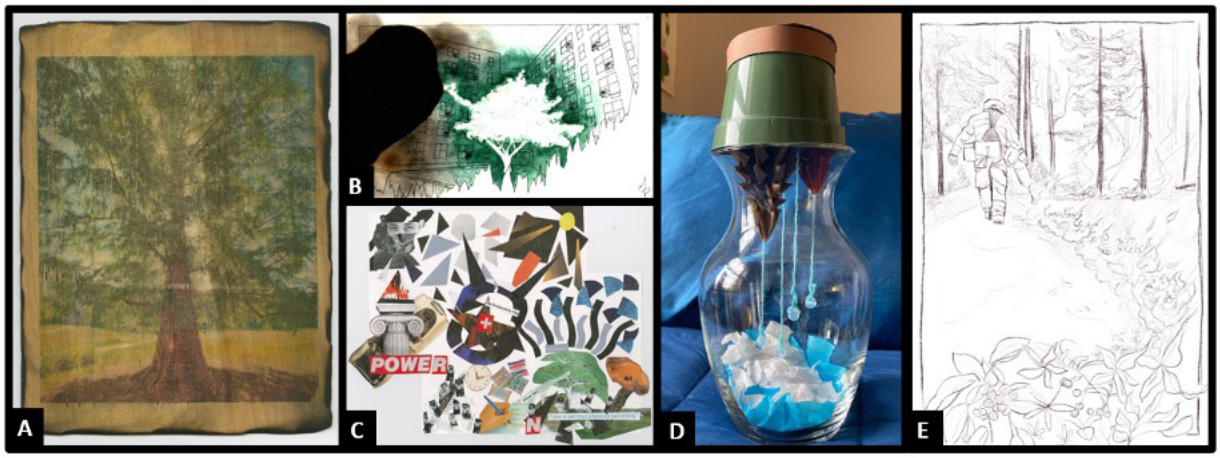

Figure 1. *(A) "Portrait of a Dawn Redwood in the Dusk of the Anthropocene" by Avery Maltz AC '25 — The Dawn Redwood was believed extinct for 150 million years until it was discovered alive in China in the 1940s. Our redwood is shown in a wood photo transfer with handmade varnish from the resin of a neighboring Cypress, a testament to hope and community care. (B) "Protector" watercolor painting by Marge Poma Alarcon '23 — This piece, painted using transpired water, is inspired by the* Prunus *tree outside the artist's apartment complex in New York City. It evokes incompleteness and discomfort in the absence of trees in residential communities, since their cooling effects are crucial to combatting the urban heat island effect. (C) "Circle Back" collage piece by Lucy Grant '23 — Positive feedback loops driven by overconsumption and capitalism are incredibly harmful to ecosystems, and they can completely shift one biome into another. Although these shifts occur slowly, they inflict massive damage to entire populations of plants and animals. (D) "Hydraulic Failure" sculpture by Virginia Griswold '23 — A sculpture and reflection of the stress responses of trees, specifically cavitation of vascular tissue and mortality in severe natural droughts. The piece captures the moment when the last water molecules (beads) leave the trees and ground in extreme drought. (E) "Spirit Power" by Carolyn Sicbaldi AC '25 — This piece is an exploration of forest fire ecology and traditional ecological knowledge upheld to generate successful regrowth of important vegetation. The title is a translation of the Interior Salish word* sumé̓s*, used to describe those who are responsible for managing fire treatments.*

processes and transform them into forms that [she] most resonated with." In addition to integrating art, this course also engaged with environmental justice issues, as well as centered papers that focused on traditional ecological knowledge, written by indigenous scholars. Another student expressed that "imperialist scientific practices attempt to divorce humans from the natural world around us to everyone's detriment, especially the poor, Indigenous peoples, and people of color. This work feels like a step towards practicing science more ethically and holistically." Through these approaches, the students reflected that they had a better understanding of the course content and felt a deeper connection to the material presented in class.

The Botanist and the Illustrator: A Long-Standing Partnership

Photo credit: Paolo Labiak

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Collections, research, descriptions, publications, photographs, and ultimately illustrations have fueled a synergistic partnership between botanist Douglas Daly and botanical artist Bobbi Angell for over 35 years at the New York Botanical Garden. Daly, as principal author, has described ca. 100 new taxa in the Burseraceae family and 15 new taxa in the Anacardiaceae, the latter co-authored with John D. Mitchell. Daly has provided the raw material—herbarium specimens, field photographs, liquid-preserved flowers, rough sketches and descriptions—and Angell has depicted all but two of the new taxa with detailed, accurate, and revealing illustrations in pen and ink.

The Burseraceae (Torchwood and Frankincense family) and Anacardiaceae (poison ivy and mango family) are sister families in the order Sapindales, which also includes the citrus (Rutaceae) and mahogany (Meliaceae) families. The pantropical Burseraceae comprise around 800 species of trees and shrubs, including the biblical myrrh and Balm of Gilead. Anacardiaceae, also with 800 species, includes many economic plants including lacquer, mango, pistachio, and cashew. Both families are important components of many of the world's floras and ecosystems, especially in the tropics.

Despite the fame and value of these two families, significant parts of their diversity had remained undescribed or misunderstood until recently. In the Anacardiaceae this is true even for genera (e.g., Mitchell et al., 2023), whereas in the Burseraceae, *Protium* and *Commiphora* contain at least 50 undescribed species each (D.C.D., pers. obs.; M. Gostel, pers. comm.), and almost half of *Canarium's* estimated 115 taxa are unnamed Asian species (pers. obs.).

Daly has collected ca. 15,000 plants under his number series, along with twice that many during fieldwork with others. His travels have focused on the regions rich in Burseraceae, including Amazonian Brazil, Mexico, Bolivia, Colombia, Madagascar, Papua New Guinea, Malaysia, and Vietnam.

Conditions are ideal when a botanist and an illustrator can collaborate long-term on a particular group of plants, both gaining familiarity with key characters, as with Daly and Angell's collaboration on the Burseraceae and Anacardiaceae (e.g., Daly 1992, 2020). A centerpiece has been the Burseraceae genus *Canarium* in Madagascar. *Canarium* has been

long known to comprise an important structural component of eastern Madagascar's moist forests, but Daly's recent work revealed that the genus comprises significant diversity there as well. Only two species of *Canarium* had been believed to exist there since the 1940s, but after Daly and two collaborators (one a Malagasy botanist) studied the genus intensively in the field and at several herbaria for several years, the taxonomic revision of *Canarium* on that island revealed 33 species, of which 27 were illustrated by Angell and published as new to science (Daly et al., 2015) (Figure 1).

With knowledge of the plant group, botanists contribute carefully chosen specimens along with a thorough description and diagnosis and sometimes sketches and field photos. All of this input flags key characteristics that the illustrator can highlight through composition and dissection. Angell need not be a specialist in the taxonomic groups she illustrates, because she has a strong background in morphology (Pell and Angell, 2016) and she understands what structures are to be depicted and how they vary. Pen and ink have been the standard type of illustration for some time because they have the great advantage that they can reveal features that are hidden or simply too small to be conveyed by scans or photographs, although photomicrography has improved in recent years.

Something both the illustrator and botanist need to possess and cultivate is the ability to work in different dimensions. The botanist may have seen the species in the herbarium (2D) and must visually "flesh out" a search image to recognize it in the field (3D). At least as remarkably, the illustrator is obliged to concatenate a 2D specimen, 2D images, and (if lucky) 3D plant parts rehydrated from 2D plant parts, and portray a 3D plant in 2D with correct disposition of the parts (e.g., orientation of an inflorescence).

An illustration is begun by roughing out a basic 'habit' from a representative herbarium specimen, showing as much as possible of the entire plant, often a leafy branchlet. Elements including upper and lower leaf surfaces and unobscured leaf nodes are arranged to display as many features as possible. Details of foliage, flower, fruit, and seed are drawn based on discussions with the author. Angell works with a dissecting microscope to view details on herbarium specimens (Figure 2). A micrometer in the lens is essential, as are accurate

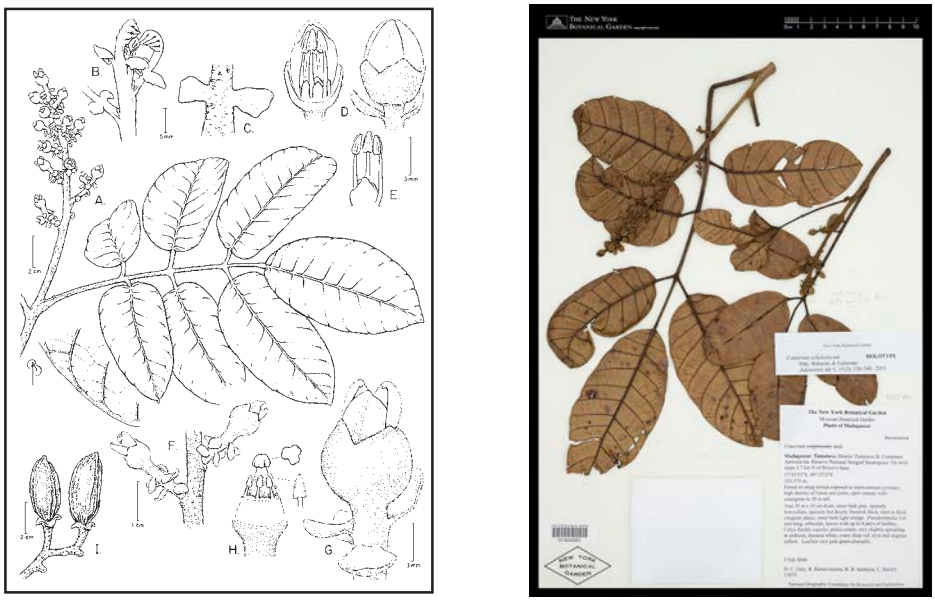

Figure 1. *(Left)* Canarium scholasticum. *(Right)* Canarium scholasticum *holotype specimen.*

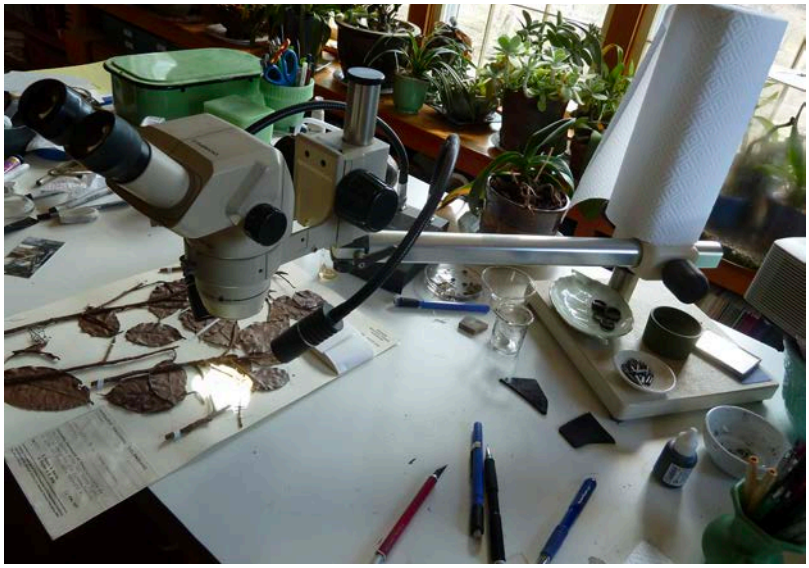

Figure 2. *Microscope setup for illustrations.*

rulers and dividers. Details are drawn at a scale appropriate to their complexity and importance, which might be a fruit enlarged to 2×, anthers at 10×, and multicellular hairs at 40×. If liquid-preserved material is not available, flowers can often be re-hydrated by gentle boiling in water with a drop of glycerin and then dissected, although only with sufficient material and permission. With the sketch reviewed by the botanist and then altered as needed, the plate is inked in. Angell uses a crowquill nib and Pelikan Tusch black drawing ink on Strathmore Bristol Board, with paper size equal to herbarium specimens and proportional for reduction to the format of journals.

The value of an illustration increases when it is multi-purposed: reproduced in floras and other publications and increasingly linked to herbarium specimen records along with field photographs, maps, phylogenies, molecular sequences, and other digital information as components of "virtual herbaria." Millions of images of herbarium specimens and many thousands of field photographs are available online in virtual herbaria or image banks, but these are of variable quality. Reputable botanical journals require that new taxa be portrayed; some permit high-resolution photographs or scans of herbarium specimens, and it is often possible to obtain very good results from photomicrographs of flowers. Illustrations continue to be optimal, however.

Studying the systematics of a group of plants is not a rapid-fire enterprise, but the synergy between the two present authors plus John Mitchell over 35 years is a highly satisfying and productive effort that has yielded 115 taxa new to science—and counting—with Angell continuing to lovingly illustrate new species of the two sisters, Burseraceae and Anacardiaceae.

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Floral Acoustic Signaling in Bat Pollination Demonstrated by Percussive Folk Music from the Northeast of Brazil

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Samba de Coco is a folk music from the Northeast of Brazil that has a significant presence in the Caatinga region, a dry forest known for its high proportion of bat-pollinated species — a unique pollination system where sound serves as a form of floral signaling. This essay explores how the unlikely combination of Samba de Coco and bat pollination led to a successful science-art connection that used music as an analogy to demonstrate the role of sound in plants.

FLORAL ACOUSTIC SIGNALING IN BAT POLLINATION AS A REMARKABLE EXAMPLE OF THE ROLE OF SOUND IN PLANTS

Plants can produce many different sounds, from the generic rustle of thousands of leaves swaying in the wind in a forest to the unique snap of a calyptra exploding from sphagnum moss, but their sound characteristics are rarely discussed. This scarcity is largely due to the inherent challenge of comprehending the biological functions of plant sounds without specialized theoretical knowledge and a creative approach to disseminating this information to a broader audience. Despite this challenge, some studies have shown that sound is a crucial factor in many biological processes in plants (Demey et al., 2023). Science-art approaches are an effective way to make botanical content more accessible and interesting to society (as demonstrated throughout this *Plant Science Bulletin* sci-art compendium), and music is a particularly successful artistic expression for explaining the sounds produced by nature (Shirley et al., 2020; Andima et al., 2021; Nguy, 2022).

The role of sound in plant-animal interactions is exemplified by the acoustic signaling in bat-pollinated flowers. These flowers take advantage of bats' echolocation sense to attract them. When using echolocation, bats emit high-frequency sounds and interpret the reflected echoes to detect objects and navigate through the environment. Chiropterophilous flowers (i.e., pollinated by bats) have specialized echoic concave parts that make them acoustically conspicuous. When bats emit sounds that reach these floral parts, a strong and multidirectional echo with a recognizable invariant signature is produced (Simon et al., 2011, 2021). This unique characteristic is combined with other peculiarities present in chiropterophilous flowers, such as large flowers, emission of sulphur

volatile compounds (unpleasant garlic or cabbage smells), and copious nectar production, making bat pollination an astonishing and unique process (Domingos-Melo et al., 2023).

Although bat pollination plays a crucial ecological role, it remains relatively unknown to society (Boero et al., 2022). This lack of awareness is exemplified in the Caatinga, the largest seasonally dry tropical forest in South America, where the significance of bat pollination as a global hotspot is unrecognized by the citizens (Domingos-Melo et al., 2023). This is not surprising given the region's lack of biodiversity awareness and educational neglect (Vieira et al., 2022). However, the Caatinga boasts a rich and unique artistic tradition, including various types of folk music such as Forró, Baião, and Xaxado, as well as Samba de Coco, which was created by Afro-descendants and native indigenous people.

Paulo Freire, widely regarded as one of Brazil's most influential pedagogues, emphasized the role of ethics and aesthetics in education through his concept of *Boniteza* (which translates to *beauty* in English) and stressed the importance of incorporating local artistic elements into the teaching and learning process (Freire, 2021). In this regard, incorporating cultural movements unique to the Caatinga into the study of its ecological processes represents an important exercise in the science-art interface. Upon contemplation of this matter, I was invited to give a lecture on Science Dissemination at the 4th Brazilian Pollination Symposium in Garanhuns, PE on October 18, 2022. As a researcher in bat pollination and an amateur Brazilian folk music player, I took this opportunity to organize a workshop where we used Samba de Coco to explain the functioning of acoustic signaling in chiropterophilous flowers. By combining science and art in this way, we hope to promote greater appreciation and understanding of our study systems in pollination biology.

THE CREATIVE PROCESS: THE UNUSUAL MIX BETWEEN BAT POLLINATION AND FOLK MUSIC

The Samba de Coco originated in several localities throughout northeastern Brazil, and its name varies depending on its place of origin. Some examples include Coco de Beira de Praia, de Roda, de Ciranda, de Umbigada, and de Raiz, which reflect the unique dance style, instruments used, and meter of the verses. Mestre Lula Calixto (1942–1999), a musician and cultural promoter from Arcoverde-PE in northeastern Brazil, created the Coco Trupé style, which is characterized by the percussion created by tapping wooden rustic clogs against a platform (Figure 1A). Other instruments used in the style include the triângulo, pandeiro, surdo, and ganzá. A significant portion of my research on bat pollination has been conducted in the Catimbau National Park, Northeast Brazil (e.g., Domingos-Melo et al., 2020, 2022; Domingos-Melo, 2021), which is located a few kilometers from Arcoverde. During 2021 and 2022, I had the opportunity to reside in Arcoverde and immerse myself in the rich cultural profusion that the 'Samba de Coco' represents in this city (Coco Raízes de Arcoverde, 2018; Coco Trupé, 2020). Given my background as an amateur Maracatu player (another folk music genre from Northeast Brazil), this experience particularly enchanted and inspired me to embark on an experiment merging art and science.

In preparation for the presentation, I collaborated with one of the local groups from Arcoverde called Samba de Coco Eremin (Figure 1F). During our meetings, we exchanged ideas and knowledge: I taught them about bat pollination in the Caatinga, while they taught me about Samba de Coco. They also took me to visit the Culture Center of Samba de Coco Raízes de Arcoverde and the Atelier of Mestre Assis Calixto (brother of Lula Calixto), who was honored by the State Government with the title of Living Cultural Heritage of Pernambuco in 2019 (Franco, 2019). Additionally, the clogs

Figure 1. *Utilization of the Northeast Brazilian folk music "Samba de Coco" as an analogy for acoustic signalling in bat-pollinated flowers. (A) Traditional wooden clogs used as percussion instruments. (B) Echolocation is used by bats during their search for flowers. (C) This process is here symbolized by the "parcela rhythm," which exhibits slower and more rhythmical tapping (visual representation of sound waves in green). (D) During the floral visitation, a long terminal call group is produced just before the bat approaches the flower and is represented by the "trupé rhythm." (E) This rhythm is characterized by tapping that gradually accelerates until it reaches the fastest tempo achievable by the performer. (F) Meeting with the Samba de Coco Eremin group to develop the idea, and (G–H) presentation and workshop held at the 4th Brazilian Pollination Symposium in Garanhuns, PE on October 18, 2022.*

used in the presentation were purchased from his studio and handcrafted by himself.

During our collaborative sessions, we drew an analogy between the percussive sound of clogs and the pulses emitted by bats that are reflected by flowers. Gonzalez-Terrazas et al. (2016) demonstrated that bats use echolocation to locate flowers, emitting a series of calls during their approach (Figure 1B). Once the flowers are identified and the bats are in close proximity, they emit a long terminal call group before visiting a flower (Figure 1C). Similarly, in Trupé performances, the clogs can be played in various ways (Coco Raízes de Arcoverde, 2019), including (1) Parcela rhythm, characterized by slower and more cadenced tapping (Figure 1D), and (2) Trupé rhythm, in which the tapping speed

progressively increases until it reaches the fastest tempo possible for the performer (Figure 1E). We used the Parcela rhythm to represent echolocation during the search for flowers, whereas the Trupé rhythm represents the long terminal call group that occurs just before visiting the flower.

THE PRESENTATION: RESEARCHERS CHALLENGED TO ROLEPLAY BAT-POLLINATED FLOWERS

During the Science Dissemination lecture, the Coco-Eremin group performed various songs featuring the Parcela and Trupé rhythms as examples of how bats echolocate when searching for and visiting flowers (Figure 1G). This was followed by a workshop in which a group of volunteer researchers from the audience participated. Coco-Eremin members taught them how to play the rhythms with their feet, and then an impromptu roleplay was performed, with a Coco-Eremin player simulating a "bat echolocating during foraging" while the volunteers acted as "flowers" and replicated the percussion to simulate the echoes (Figure 1H). The group followed the Parcela rhythm at first, and in some moments increased the speed to the Trupé rhythm (simulating a floral visit), with the researcher volunteers following suit. It was humorous to watch the researchers on stage attempting to match the speed of the skilled Coco player. After a couple of rounds, the "flower that best reflected the sound of the bat" was declared the champion. The audience found this playful exercise amusing and exciting.

PERSPECTIVES: USE OF MUSIC TO BUILD ANALOGIES ABOUT THE ROLE OF SOUND IN PLANTS

Expanding on our successful endeavor, there's compelling potential to explore further aspects of ecoacoustic signaling in chiropterophilous plants. The rich complexity of this process offers numerous avenues for science-art experiences, complemented by the creative potential of Samba de Coco. Extending this interdisciplinary approach to educational settings such as schools and non-formal learning environments could broaden its impact and foster curiosity among diverse audiences.

The recent shift in the terminology from "plant blindness" to "plant awareness disparity," while addressing the ableism inherent in the former, also emphasizes the extensive consequences of neglecting plants on our attitudes, knowledge, and interest in them (Parsley, 2020). As we move away from a metaphor that exclusively centers on visual processes, it is appropriate to acknowledge the importance of other sensory modalities in educating about plants. In this context, we demonstrate that music can be a compelling alternative for creating intricate analogies that highlight the role of sound in plants. Such analogies not only serve to illustrate the importance of sound in the life of plants, but also stimulate an emotional connection with nature that can motivate people to study them. In our case, with a touch of poetic imagination, one might envision the Caatinga as a nocturnal dance floor, where thousands of chiropterophilous flowers sway to the beat of a joyous Samba de Coco, in a mesmerizing performance rhythmed by the bats' echolocation.

Acknowledgments

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Cross-Pollination: Building a Co-Taught Course to Examine Art and Sex Through the Lens of Botany

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Nearly a decade ago, Bucknell University—a small, private, liberal arts institution in central Pennsylvania—instituted a new sophomore-level requirement titled Integrated Perspectives (IP). Taught by instructors from two different disciplines, courses under the IP umbrella are meant to introduce students to an area of study through the combined efforts of professors whose disparate academic backgrounds meet in a sort of pedagogical "sweet spot." When successful, this approach challenges both the students and the professors in often unexpected ways, with varying degrees of both discomfort and engagement that can engender impactful learning outcomes.

Driven by overlapping interests in plants, art, and diversity in sex expression, Anna Kell (Department of Art and Art History) and Chris Martine (Department of Biology) developed a course that integrates the perspectives of a visual artist and a botanist. *Art & Sex Through the Lens of Botany* seeks to impart the importance of making connections across disciplines and the value of visual literacy across academic lines. The course introduces foundational concepts in each field and encourages students to integrate and explore these different systems of knowledge and their intersections.

In addition to developing fluencies related to both general botany and studio art, the goal of the course is that students demonstrate a variety of new strengths including (1) the ability to recognize, construct, and evaluate connections among different intellectual methods, ways of learning, and bodies of knowledge; (2) the ability to identify the various parts of a flower and discuss their significance and role in sexual reproduction in plants; (3) increased awareness of visual forms of communication, including artistic expression, data visualization, and observation; and (4) a broader understanding of the role of sexuality in the science of biology and in the formation of cultural beliefs and biases. Through these approaches, students engage in cultural dialogue regarding our perceptions of normativity in sexual expression—often using the flower (including its depiction in art) and the wide variation in angiosperm sex expression as a starting point. By examining the impressive diversity of sexual systems and forms present in flowering plants (through dissections, microscopy, comparative approaches, and artistic representation), students are consistently challenged to question what is "normative" when considering the myriad means by which organisms (including our own species) "do" sexuality.

As they build their botanical acumen, students are then challenged to create artworks applying their evolving knowledge and understanding to their own perceptions and experiences related to sexuality, gender expression, and other sociocultural issues or cultural phenomena they identify as important to them. The hope is that this interdisciplinary approach to botany and art not only gives students a new (or initial) appreciation and understanding for each academic discipline, but also gives an awareness of the ways these students might contribute meaningfully to cultural dialogue (including on topics related to human sexuality) through the integration of science and art.

The pedagogical mission of the course is largely achieved through hands-on lab experiences and creative projects, each requiring extended course periods and ample teaching/work space for the typical enrollment of 24–30 students. The current iteration of the class meets twice a week for 80 minutes and occupies two adjacent lab classrooms with large open bench spaces; there is also dedicated space in our nearby collections spaces for storage of in-process and completed assignments. Students in the course complete a number of "sci-art" projects, including the following examples:

1. Wearable plant-pollinator interaction art pieces in which the pollination process is performed and recorded in short video clips. Done in groups, this activity promotes an understanding of coevolution, coadaptation, and biological interactions. For example, a group of students majoring in Math, Neuroscience, Studio Art, and Management constructed costume pieces that were worn as part of a greenhouse-based "ballet" performance in which the Math student (also minoring in Dance) played a *Trochetia blackburniana* flower visited by the Neuroscience student acting as a day gecko.

2. Repeated pattern wallpaper designs inspired by plant reproductive strategies including, in one case, a treatment reflecting on the deception associated with bee orchid (*Ophrys*) pollination and, in another, the sex-changing and thermogenic habits of skunk cabbage (*Symplocarpus foetidus*).

3. Projects using herbarium paper as a canvas, including:

    - Artistic documentation of floral dissections using various species and reproductive morphologies, with attention to representations of "maleness," "femaleness," and cosexuality.

    - "Cultural specimen" sets expressing a particular feeling, place, personal experience, or wider cultural phenomenon. As an example, one Biology student cut a Pride flag into scraps and then reassembled them into specimens of national flowers for countries in which being gay is considered a crime. These were then mounted as herbarium specimens with labels identifying the countries and the sentencing associated with the "crime" of homosexuality.

    - Bio-cultural commentaries built around scraps of textiles featuring floral motifs. For example, student Sophie McQuade (Figure 1) chose a swatch of fabric featuring a bleeding heart (*Dicentra*) in flower as an inspiration for a reflection on queer identities.

Figure 1. "Bleeding Hearts" *by Sophie McQuade, 2021, gouache on herbarium paper. A bio-cultural commentary created around a single round piece of cloth (upper right) with a floral motif representing a bleeding heart (*Dicentra*). Artwork completed as part of the A*rt & Sex Through the Lens of Botany *course at Bucknell University (Lewisburg, PA, USA) and included with permission from the artist (Instagram @sophiemcquaideart).*

At the conclusion of each semester of the course, Bucknell's Rooke Science Center becomes a gallery space where students in Art & Sex Through the Lens of Botany display their work as part of a short-term exhibition—with the entire campus community invited to the opening. Some of the pieces have now hung in hallways, labs, and classrooms for years, alongside research posters and bulletin boards displaying journal articles and campus flyers—a daily reminder that creativity and art have a place in the teaching of science.

Botany 2024!

Featured Speakers

Colin Khoury
Plenary
Address

Mark Merlin
Distinguished
Ethnobotanist

Kaya DeerInWater
Regional Botanist

Jenny Xiang
Incoming
BSA President

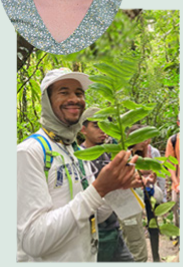
Joyce Gloria Onyenedum
BSA Emerging Leader

Kathleen Kay
Annals of
Botany

David Tank
Incoming ASPT
President

Cynthia Jones
Kaplan Lecture

Belong in Botany Panel Discussion
Perspectives on Success in the Biological Sciences
Moderated by Karolina Heyduk

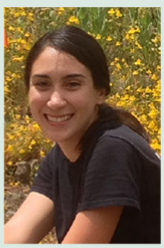


Josh Felton

Ana Flores

Joyce
Navarro

Charles
Bush



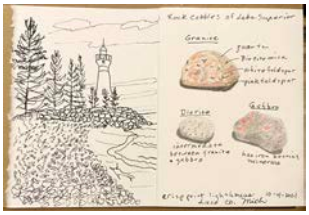
Katherine
Toll

Morgan Ruelle
SEB Mid-Career
Award

Botany 2024!

Workshops and Field Trips

Have Some Fun and Learn Something new!



West Michigan's Natural Communities Sampler

Sphagnum Bog, Oak Barren and more

Flower Creek Dunes Nature Preserve

Kellogg Biological Station

Ferns and Lycopods of Yankee Springs

Nature Journaling Science and Art

Hudsonville Nature Center

Frederick Meijer Garden and Sculpture Park

White Water Rafting

A Full Slate of Workshops

Full Day
Half Day or Two Hour!

Sign up on the
Conference Website

Introduction to Phylogenetic Comparative Methods in R

Data Analysis and Visualization In R

SNPs, genes, genomes: using assembled genomes for answering evolutionary questions

Biodiversity data wrangling: Linking large phylogenies with species traits and ecologies

Common methods in leaf gas-exchange research: an introduction to measurements, theory, and data analysis

How to Tackle Teaching Plant Life Cycles

Winter twig and fruit identification

Conservation through Ethnobotanical Relationships

SISRIS: Supporting Inclusive and Sustainable (collections-based) Research Infrastructure for Systematics

Genome Skimming: A Bioinformatics Approach to Assembly-Free Analysis of Genomic Information

Traditional Cyanotype Printing with Jessie Swimeley

Ethnobotany, natural products, and microbiomes through a One Health collaboration

3D Printing for Science: From Design to Optimize
Seeing Seeds: An Artistic Investigation

Planting Inquiry in Biology Classrooms

BSA Publications Updates

SEARCH FOR NEW EDITORS-IN-CHIEF FOR *AJB* AND *PSB*

The BSA has been very fortunate to have Dr. Pamela Diggle as the Editor-in-Chief of the *American Journal of Botany* (*AJB*) and Dr. Mackenzie Taylor as the Editor-in-Chief for the *Plant Science Bulletin* (*PSB*) for almost 10 years! Both Pam and Mackenzie will complete their second 5-year terms in December 2024.

A search committee to recruit new Editors for these important BSA publications was formed in February 2024 and includes Emily Sessa (Chair), Eugenio Larios, Nora Mitchell, Andy Schnabel, Mackenzie Taylor, Amy McPherson, and Richard Hund.

The committee launched the search process during the week of February 26, with an application deadline of April 5, 2024. Interviews will take place in late April into May, and a recommendation to the Board will be made by early June. Ideally, offers will be extended to candidates for both publications before the Botany meeting in mid-June, but otherwise by the end of July. The terms for the new EiCs will begin in January 2025.

By Amy McPherson
BSA Director of Publications

E-mail: amcpherson@botany.org

AJB AND *APPS* OPEN CALL FOR ASSOCIATE EDITORS

In late August 2023, the BSA publications team launched an open call for Associate Editors for *AJB* and *Applications in Plant Sciences* (*APPS*), with the goals of adding depth of expertise and improving diversity on our editorial boards. We strongly encouraged applicants from underrepresented groups and regions to apply; by the end of September, we received 83 applications from over 20 countries. *AJB* invited 13 and *APPS* invited 9 applicants to join our editorial boards as Associate Editors; other applicants were encouraged to become or remain engaged with the journals as authors and reviewers (and Early Career Advisory Board or Publications Committee members). Most terms began in November 2023, and the new AEs will be assessed after 1 year to determine whether the arrangement is working well for both parties.

New *AJB* Associate Editors, as a result of the Open Call*:* Liming Cai (University of Texas-Austin), Myong Gi Chung (Gyeongsang National University, South Korea), Andrés J. Cortés (Colombian Agricultural Research Corporation, Colombia), Lucía DeSoto (Complutense University of Madrid, Spain), Carole Gee (University of Bonn, Germany), Brenda Grewell (USDA ARS and University of California Davis), Eugenio Larios (Universidad Estatal de Sonora, Mexico), Elena Lopez Peredo (Rochester Institute of Technology), Giacomo Puglielli (University of Seville, Spain), Susan Rutherford (Wenzhou-Kean University, China), Yuval Sapir (Tel Aviv University, Israel), Elizabeth Stacy (University of Nevada Las Vegas), and Juan Carlos Villarreal A. (Université Laval, Québec, Canada). For a list of the entire editorial board, see https://bsapubs.onlinelibrary.wiley.com/hub/journal/15372197/homepage/editorialboard.

New *APPS* Associate Editors, as a result of the Open Call: Rob Baker (National Park Service), Mario Blanco-Sánchez (Netherlands Institute of Ecology, The Netherlands), Gordon Burleigh (University of Florida), Vadivelmurugan Irulappan (University of Missouri, Columbia), Gianalberto Losapio (University of Lausanne, Switzerland), Giuseppe Diego Puglia (National Research Council of Italy), Dustin Ray (University of Minnesota-Duluth), Aarón I. Vélez-Ramírez (Universidad Nacional Autónoma de México), and Yunjian Xu (Yunnan University, China). For a list of the entire editorial board, see https://bsapubs.onlinelibrary.wiley.com/hub/journal/21680450/homepage/editorialboard.

APPS RECRUITING EDITOR

Applications in Plant Sciences held an open call for a new Recruiting Editor in October-November 2023 and received 11 applications from a geographically diverse pool (4 applicants from Europe, 2 from the US, 2 from Pakistan, 1 from India, 1 from Malaysia, and 1 from Mexico). After interviews and careful consideration, Tilottama (Tilo) Roy, of Missouri Western State University, was offered the position and began working with the journal in early February 2024.

ARTIFICIAL INTELLIGENCE AND PUBLICATIONS: GUIDELINES

At the Botany meeting in Boise, the editors of *AJB*, *APPS*, and *PSB*, along with the Director-at-Large for Publications, met and discussed the challenges and opportunities that artificial intelligence (AI) will potentially offer to science. An ad hoc committee, chaired by Theresa Culley (University of Cincinnati), was formed in September 2023 to discuss how generative AI is changing publishing and what guidelines we should be providing for authors, reviewers, and editors. The committee is meant to have a one-year lifespan, roughly September 2023 to June 2024. In addition to drafting guidelines, the committee will produce an article for the *Plant Science Bulletin* that relates their findings about the AI landscape and what it means for BSA publications. Stay tuned!

BSA Leadership Responds to News of Duke University's Herbarium Closure

In February 2024, Duke University announced the closure of its 100-year-old herbarium, the second-largest private herbarium in the United States. The decision led to protests from university scientists and researchers from around the globe. Home to 825,000 specimens, including vascular plants such as flowers and trees, to a large collection of algae, lichens, fungi, and mosses, the herbarium was deemed too expensive to maintain.

BSA President Brenda Molano-Flores, on behalf of the Society, joined other scientific leaders by contacting the leadership at Duke to express the following thoughts, and to prompt reconsideration of their decision.

I am writing on behalf of the Botanical Society of America, a professional scientific society representing 3,000 botanical scientists worldwide, to emphasize our deep concern regarding the planned closure of the Duke University Herbarium and relocation of its collection. We urge you to reconsider this decision which will have dire consequences for the second largest private herbarium in the United States, its invaluable collections of vascular plants, bryophytes, lichens, fungi and algae, and for current and future scientific researchers.

The Duke University Herbarium serves as a crucial repository of botanical diversity, providing researchers with essential resources for studying plant taxonomy, distribution, ecology, and evolution. These collections represent a tangible record of our planet's botanical heritage and are indispensable for advancing our understanding of the natural world. The closure of the Duke University Herbarium and relocation of its specimens would not only represent a loss of scientific resources but also hinder efforts to address the most pressing scientific issues of our time: climate change and global biodiversity loss. Without access to these invaluable collections, especially for plant scientists in the Southeastern United States which is the most biodiverse region of the country, researchers would be deprived of essential tools for understanding and combating the environmental challenges we face.

With this divestment and dispersal of a world-renowned scientific collection, Duke is ceding its position as a top research center and strongly indicating it no longer values the support and training of the next generation of scientists. Generations of outstanding plant biologists have been trained through the Duke Herbarium. Duke undergraduate and graduate students in Agriculture, Biology, Environmental Science and Policy, and Earth and Climate Science will lose access to a world-class archive of plant biodiversity that has supported student research and training for over a century. We encourage you to continue the Duke legacy in biodiversity science by supporting this critical resource.

We understand the financial constraints that institutions often face. The long-term funding of a Herbarium and its curators is not insignificant. However, we believe that the long-term benefits of maintaining the Duke University Herbarium far outweigh the cost. We urge you to explore alternative solutions and potentially a combination of solutions, such as increased funding (Duke's endowment consistently ranks as one of the largest at US universities), partnerships, or community and crowd-funded support, to ensure the continued operation of this important herbarium. Rather than scattering these collections, we must invest in them and maximize access to the wealth of knowledge they hold about the past, present and future of our planet.

Demonstrate that you value biodiversity, research and the training of our next generation of top-notch plant scientists and preserve the world-class scientific collections you have while keeping them in their home at Duke. The Botanical Society of America stands ready to support your efforts to maintain the collection at Duke and looks forward to a positive resolution to this matter. Thank you for your attention to this urgent issue.

Sincerely,

Brenda Molano-Flores
President on behalf of the BSA Board of Directors Botanical Society of America

MEMBERSHIP NEWS

#PlantJoy Campaign

Brenda Molano-Flores, the current BSA President, would like to invite you to share your **#PlantJoy** to help create a community-wide celebration of how plants and botany bring us joy. As you may remember, "**Finding the joy—tall tales of a plant lover**" was her Incoming Presidential lecture at last year's Botany conference (a recording is available at https://www.youtube.com/watch?v=sBt3Xn7AevM!).

How can you share the ways plants bring you joy?

- Share stories and videos on social media with the hashtag: **#PlantJoy**
- Email PlantJoy@botany.org with items you would like to share on the #PlantJoy landing page: https://botany.org/plantjoy.html
- You can also add to the word cloud on the #PlantJoy landing page at https://www.menti.com/alkfotz2c5gk!

To get started, take a look at Brenda's #PlantJoy introduction video (https://youtu.be/S3H5dH0fKlA?si=2a9YaGHneuQBRRDG), and hopefully you will be inspired to share how you find joy in your botanical research, interaction with plants, nature, and more!

Thank you, in advance, for sharing how you find joy in your relationship with plants. If you have any questions, email plantjoy@botany.org.

By Amelia Neely

BSA Membership & Communications Manager

E-mail: ANeely@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

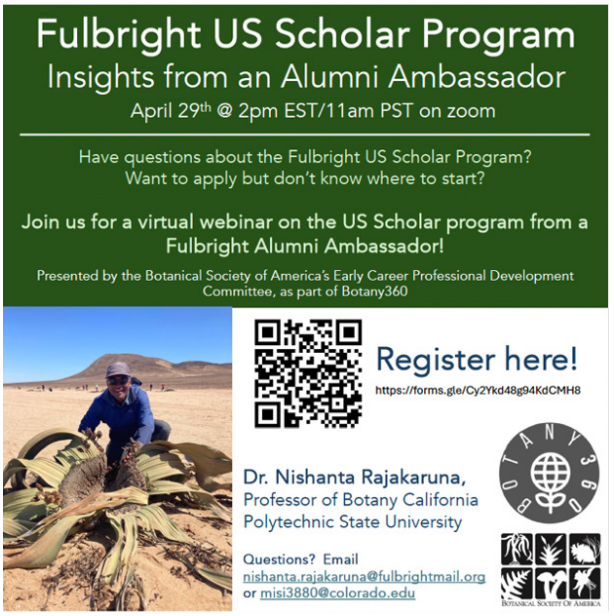
plant science community throughout the year with professional development, discussion sessions, and networking and social opportunities. To see the calendar, visit www.botany.org/calendar. If you want to coordinate a Botany360 event, email aneely@botany.org.

Upcoming Botany360 Virtual Events

- Fulbright US Scholar Program: Insights from an Alumni Ambassador https://botany.org/calendar/display/date/20240429/viewtype/event/eid/44 April 29, 2024, 2–3 pm EST
- Longwood Gardens Fellows Program Informational Webinar [sponsored event]https://botany.org/calendar/display/date/20240508/viewtype/event/eid/45 May 8, 2024, 1–2 pm EST

Recent Botany360 Event Recordings

- Applying to Graduate School Q&A Panel (September 26, 2023) https://www.youtube.com/watch?v=ETdaLo7Hwd8



- Reviewing Papers for Scientific Journals (December 13, 2023) https://www.youtube.com/watch?v=8mwBWvY0gR8
- Getting Involved in Service to BSA and Beyond (January 8, 2024) https://youtu.be/kh-btx0L9c4?si=dSARRUiG2Jj8S011

Other Recordings of Interest Related to the Upcoming Botany Conference

- **Ace It! - Write a Better Title** (March 2, 2022) https://www.youtube.com/watch?v=e2_CkFtBcI4
- **Ace It! - Write a Better Abstract** (March 23, 2022) https://www.youtube.com/watch?v=dbPGAr9_GyE
- **Making the most out of Botany 2023 - A Student Conference Guide** (May 26, 2023) https://www.youtube.com/watch?v=1CiRBSs45kw

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.

The latest member spotlights:





Find the following profiles at https://botany.org/home/careers-jobs/careers-in-botany/bsa-spotlight-series.html.

- **Shweta Basnett**, Postdoctoral Fellow, University of Maryland, College Park
- **Blaire M. Kleiman**, Graduate Student, Florida International University
- **Francis J. Nge**, Systematic Botanist, Royal Botanic Gardens and Domain Trust, Sydney, Australia
- **Trinity Tobin**, Undergraduate Student, SUNY Cortland
- **Jaqueline Alves Vieira**, Graduate Student, São Paulo State University (IBILCE/Unesp - Brazil)

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

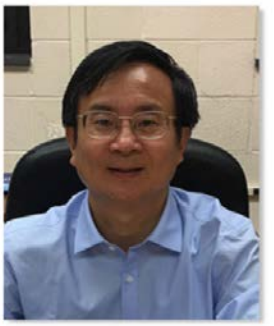
BSA PROFESSIONAL HIGHLIGHT SERIES

In 2023, we included a **BSA Professional Member Highlights** section each month in the *Membership Matters* newsletter. Starting in 2024, both Professional and Early-Career BSA members will be highlighted in the ***Spotlight Series***. If you want to be part of this year's spotlight series, email aneely@botany.org.

Dr. Jennifer Ackerfield
Head Curator of Natural History Collections and Associate Director of Biodiversity Research
Website: https://jenniferackerfield.weebly.com/

Jennifer coordinates the growth and improvement of the natural history collections, supports biodiversity research efforts, and manages herbarium staff and volunteers working with the collections. Throughout her career, Jennifer has traveled extensively throughout Colorado documenting its rich floristic diversity. This extensive knowledge led her to write the Flora of Colorado, with the goal of helping anyone identify the plants of Colorado with ease. Jennifer also leads a research program focused on documentation of biodiversity through targeted floristic inventories, systematics and taxonomy of western North American groups such as native thistles (Cirsium), and unraveling the origins of plant diversity in the Southern Rocky Mountains through biogeographic studies. Jennifer regularly collaborates with organizations and agencies across the state, leads field trips and workshops, and initiates community participatory science campaigns. She also loves teaching and sharing her passion for botany to students of all ages.

Dr. Hong Ma
Professor of Biology at the Pennsylvania State University



Dr. Hong Ma is a professor of biology and holder of the Huck Chair for Plant Reproductive Development and Evolution, at the Pennsylvania State University. He has worked with students, post-doctoral scientists, and collaborators to understand the molecular mechanisms regulating plant reproduction and to reconstruct angiosperm phylogenies using nuclear genes, with an aim to learn about factors that shape plant evolution and diversity. Among the angiosperm groups he and his colleagues have studied are large families, including Asteraceae, Orchidaceae, Fabaceae, Poaceae, Brassicaceae, Rosaceae, Solanaceae, and Cucurbitaceae. He is actively involved in the education and training of students at different levels, particularly undergraduate and graduate students, to help them prepare for their careers in a variety of fields. He is especially happy to meet with young conference attendees and share some thoughts and experiences related to career development.

Dr. Ingrid Jordon-Thaden
Director of Botany Garden & Greenhouses in the Department of Botany at the University of Wisconsin Madison

X (formally Twitter)**:** @IThaden
Websites: https://jordonthadenbotany.weebly.com/ and https://jordonthaden.botany.wisc.edu/

Ingrid is directing a team that cares for a living collection of plants for teaching in the Department of Botany at the University of Wisconsin Madison. As Director of the Botany Garden and Greenhouse she helps provide the live plants for many courses, gives tours, and ensures it continues to be a prominent botanical education facility on campus and in southern Wisconsin. She is currently teaching botany for non-majors at the University of Wisconsin Madison and is a Research Associate of the Florida Museum of Natural History. Her research aims to explore questions regarding speciation processes and adaptations in plant species at the nexus between population genomics and phylogenetics. In particular, she is fascinated with the myriad of modifications during gametophytogenesis in plants and how that affects the survival and adaptation of a species. Ingrid is also currently serving as the Secretary of ASPT.

BSA LEGACY SOCIETY

Thank you to all of our Legacy Society members for supporting BSA by including the Society in your planned giving. We look forward to hosting you at this year's **Legacy Society Reception** at **Botany 2024 in Grand Rapids, Michigan**. If you are interested in joining the Legacy Society, you are welcome to come to the event and sign up in person or by filling out this form at any time: https://crm.botany.org/civicrm/profile/create?gid=46&reset=1.

We would like to welcome the following new 2023-24 Legacy Society members:

Erika Jeannine Edwards

Steven and Joan Handel

Lena Struwe

Qiuyun (Jenny) Xiang

1 Anonymous Member

The intent of the **Botanical Society of America's Legacy Society** is to ensure a vibrant society for tomorrow's botanists, and to assist all members in providing wisely planned giving options. All that is asked is that you remember the BSA as a component

in your legacy gifts. It's that simple—no minimum amount, just a simple promise to remember the Society. We hope this allows *all BSA members* to play a meaningful part in the Society's future. To learn more about the BSA Legacy Society, and how to join, please visit: https://botany.org/home/membership/the-bsa-legacy-society.html

2023 GIFT MEMBERSHIP DRIVE DRAWING WINNER

Thank you to everyone who purchased gift memberships during the 2023 Gift Membership Drive (October through December 2023), and congratulations to the Botany 2024 registration drawing winner, **Stephen Mills**, a student at Purdue University.!

You can purchase one- or three-year gift memberships at any time for both students and developing nations' colleagues. Want to donate a gift membership to students or developing nations' colleagues instead? Simply put an X in the name and email recipient fields. Visit www.crm.botany.org to get started.

NEW 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.

FROM THE *PSB* ARCHIVES

60 years ago

The Plant Science Bulletin *was nearly shelved 10 years after its first issue. This note from the editor goes on to explain the results of the study to reevaluate the economics of* PSB. *There is only one issue of* PSB *from 1964 in the BSA archives, possibly due to this ongoing study.*

"Sometime last year, while I was 9,000 miles away from home in the Philippines, I received a most unnerving bit of communication from a colleague back home: *Plant Science Bulletin* was on the verge of being scotched, or at best it would be emasculated. Pressure was being put on the powers that be in the Society to introduce drastic economies which might decrease its stature, reduce it to the category of a hand-out, or even eliminate it entirely!

[. . .] your editor saw bloody red and immediately dashed off a scathing letter saying in effect: Don't touch P. S. B.; I knew it when it was a fledgling; it should not be cheaply printed; its founders were friends and mentors of mine; I knew why it was begun; it has served a great and noble purpose; it is not a chit-chat sheet; etc. Letters came back saying cool off old boy; the situation is in hand; we will wait until you return; no one is going to junk P. S. B. summarily and without a chance for a hearing. In short, President Alexopoulous wisely appointed a committee to examine P. S. B. and "to study the whole matter . . . and to make ... recommendations . . . to the Council at its Boulder meeting in 1964," and to give special attention to how "the cost of production ... [might] be reduced" and to "a general re-evaluation of the Bulletin."

-Stern, William L. 1964. A note from the Editor**.** *PSB* 10(1): 4-5

50 years ago

"The first biographical sketch that appeared [in *PSB*] was the one of Charles Edwin Bessey published in volume four, issue five, which was also the first issue edited by Harriet B. Creighton who succeeded Professor Fuller. The first obituaries, those of Harley Harris Bartlett and Ezra Jacob Kraus, were published in volume six. Since then biographical notes have appeared in every volume, except volumes ten and fifteen. The peak volume was number seven, with eleven biographical notes. In order that information in these biographical notes may be more readily accessible to the Botanical Society of America members, scholars, and historians, the accompanying index has been prepared."

-Stuckey, Ronald L., and W. Louis Phillips. 1974. Biographical Sketches and Obituaries in Publications of the Botanical Society of America — An Index**.** *PSB* 20(1): 5-6

40 years ago

"The 2nd International Wetlands Conference will be held in Trebon, Czechoslovakia June 13-23, 1984. The meeting is sponsored by the INTECO Wetlands Working Group, SCOPE, UNESCO/MAB, and the Institute of Botany, Czechoslovak Academy of Sciences

-Meetings and Courses 1984. *PSB* 30(1): 5

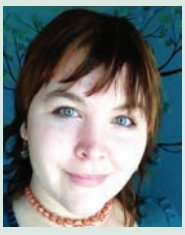
Seeking Flora/Field Guide Recommendations to Update BSA's State-by-State Botanical Resource Pages

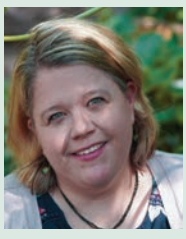
The BSA Education Committee is seeking to update the state-by-state resource lists available on the botany.org website. We're looking for information about up-to-date floras and field guides, academic programs (where in your state can people pursue a botany-related degree?), organizations, and quality, durable web resources focused on the botany of the state or region. *To start, we are focusing on U.S. states and territories,* but we may expand this project to cover other regions where BSA members live and work if this project is successful and members find the information useful.

The Committee's starting goal is to have the most comprehensive undergraduate student-appropriate state flora/field guides listed for each state. This resource will be useful for faculty who want to refer students to their local flora, or for botanists moving from one region to another. We appreciate any help you can provide in creating this useful resource that doesn't appear to be easily found elsewhere.

It should take less than 5 minutes to submit your resource(s), which will be vetted by the Education Committee and then added to the botany.org website. To submit a resource, please use this link: https://forms.gle/VjpHPYM9pVKJ4dmh9.

"USA-based BSA members: Which flora or field guide would you recommend undergraduates use to identify plants in your state or region?"





By Dr. Catrina Adams, *Education Director*

Jennifer Hartley, *Education Programs Supervisor*

ROOT & SHOOT RCN DEVELOPING A NEW CULTURALLY RESPONSIVE MENTORING CERTIFICATION PROGRAM TO PILOT IN FALL 2024

A new working group has been established by the ROOT & SHOOT RCN to create a culturally responsive mentor certification program for plant scientists. The working group holds a large group meeting once a month, and weekly smaller meetings with various subgroups. All working group members receive stipends. The plan is to create/compile a pilot cohort-based mentor certification program to be ready to be evaluated in Fall 2024. There will likely be opportunities to participate in piloting the new program announced in late summer on the ROOT & SHOOT website (https://rootandshoot.org) and advertised in future BSA newsletters and via social media. More information on the charge and structure of this working group is available on the ROOT&SHOOT website: https://rootandshoot.org/working-group-on-culturally-responsive-mentoring/

The working group includes a diverse group of 23 members in total with a wide range of experiences related to culturally responsive mentoring. The working group members were recruited from the seven ROOT & SHOOT participating societies. Thanks to the 13 BSA-affiliated members representing our society in the working group!

Jordan Argrett

Summer Blanco

Cael Dant

Caitlyn Elliot

Amy Faivre

Ian Gilman

Laura Gough

Juliana Harden

Janet Mansaray

Renee Petipas

Cierra Sullivan

Jess Szetela

Mariana Vazquez

ROOT & SHOOT RCN SPONSORED BYSTANDER INTERVENTION WORKSHOPS OFFERED IN MAY FOR BOTANY 2024 ATTENDEES

Many BSA members took advantage of free Bystander Intervention Training workshops last spring in advance of the Botany 2023 conference in Boise. The ROOT & SHOOT RCN is offering these workshops again in 2024 for members of the RCN who are

planning to attend Botany 2024 in Grand Rapids, MI. The workshops are again provided by the ADVANCEGeo partnership (https://serc.carleton.edu/advancegeo/workshops/topics.html). This year's spring workshop is scheduled for May 22 from 11 a.m. to 2 p.m. EDT.

The RCN is also offering an "advanced" 1-hour practice-heavy "refresher" version of the training for those who attended the workshop last year, or who are looking for more practice. This refresher workshop will be held on May 28 from 3 to 4 p.m. EDT.

Learn more about these workshops and sign up to participate at: https://rootandshoot.org/2024-bystander-intervention-workshops/

PLANTINGSCIENCE SPRING 2024 SESSION UPDATE

The Spring 2024 session of PlantingScience is in full swing right now. We were so pleased with the enrollment this session—we had 20 teachers apply to participate! This was especially positive because about half of these teachers were past participants and the other half were new to us. In total, the session has engaged 540 students across 147 inquiry projects, comprising a nice mix of middle- and high-school students, and even one undergraduate class in India! The topics studied in this session include seed germination, tissue structure and behavior, photosynthesis, C-fern development, and genetics. Many thanks to our wonderful cohort of liaisons this session, and the 102 mentors who have stepped up to work with our student teams!

PlantingScience also received a pleasant surprise when we learned we had been featured in an article with our service provider and website host, HubZero. Leading up to the Digging Deeper F2 research initiative during our Fall 2023 session, the PlantingScience team and HubZero worked together to update and improve our platform. Read more about these updates at http://bit.ly/pshzfeature.

We are now looking ahead to the continuation of the Digging Deeper F2 research with the Fall 2024 cohort. Applications for the Fellows opportunity for early career scientists have closed and we are making selections, which will be announced soon! We're pleased to report that our mentor pool has increased by over 100 mentors since August of 2023, but we anticipate another big session this coming fall. If you or anyone you know is interested, please join us! Visit https://plantingscience.org/getinvolved/mentor to learn more.

Curious about the Conference Logo?

A lot of thought goes into the Botany Conference logo each year. The logo for *Botany 2024 – Resilience in a Changing World* was informed by our desire to select plants that are native to Michigan and exemplify resilience in various ways.

Arnica cordifolia Hook. - Heartleaf Arnica:
The showcased plant is *Arnica cordifolia* Hook., the heartleaf arnica. A member of the Asteraceae, this perennial species is endangered in Michigan but thrives across western and northern North America. Known for its adaptability to both shade and sun, moderate fire resistance, and a potential need for disturbance in order to be successful, the heartleaf arnica has a long history of medicinal use.

Zizia aptera (A.Gray) Fernald - Prairie Golden Alexanders:
The plant with yellow-flowers in flat-topped umbels is *Zizia aptera* (A.Gray) Fernald, also known as Prairie golden alexanders, Heartleaf golden alexanders, or Meadow zizia. While this species in the Apiaceae is threatened at the state level, it maintains globally security as a short-lived perennial, relying on re-seeding for its persistence.

Cypripedium parviflorum Salisb. - Yellow Lady's Slipper:
The yellow lady's slipper, *Cypripedium parviflorum* Salisb., is a familiar orchid that is widespread across North America with several varieties commonly recognized. The yellow lady's slipper is globally secure with a conservation status of least-concern.

Woodwardia areolata (L.) T. Moore - Netted Chain Fern:
In the background of the logo is the beautiful *Woodwardia areolata* (L.) T. Moore (= *Lorinseria areolata* (L.) C.Presl), the netted chain fern. Native to the southeastern United States, this globally secure member of the Blechnaceae ranges northward along the eastern coast and has a historical presence in Michigan, last seen in Van Buren county (southwest of Grand Rapids) in 1880. Although it hasn't been seen in Michigan for over a century, it is presumed to be present, so keep a keen eye while enjoying any conference field trips—and document any sightings with photos—as the rediscovery of this species during our conference botanizing would be a remarkable event.

Conference logo designed by Melanie Link-Perez and Johanne Stogran

Botany360 Webinar: How to Be a Successful BSA Student Representative

We were excited to lead a Botany360 webinar earlier this year on "How to be a Successful BSA Student Representative." If you missed it and would like to access the slides from the presentation, go to https://bit.ly/40IrhdB, and be sure to email us at feltonjosh@icloud.com and elishartung@gmail.com if you have any questions. (For more information on the Botany360 series, see the Membership article in this issue.)

By Eli Hartung and Josh Felton
BSA Student Representatives

ROUNDUP OF STUDENT OPPORTUNITIES

It's that time of the semester where you start to compile every opportunity you want to apply to into one list. To make this easier for you, we have compiled a list of all the opportunities we know about. **Even if the deadline of this application cycle is passed for this academic year, make sure to check by the end of this year for the next application cycle and expect that the deadline for the next year will be around that date.** We have divided these into categories for easy browsing that include the following: BSA Grants and Awards, Fellowship, Research Awards, Broader Impacts, Short Courses and Workshops, Job Hunting, and ways that may help you to travel to Botany 2024. The list is long! So we've provided a link that you can use to access funding opportunities: http://tinyurl.com/2024bsaopportunities.

Of course, all the grants and awards information will also be announced and reminded via the BSA social media, so make sure to follow us on Facebook (Botanical Society of America), X (@Botanical_), BlueSky (@botsocamerica.bsky.social) and Instagram (@botanicalsocietyofamerica) and stay updated! Also feel free to reach out to your

BSA student representatives Josh (feltonjosh@icloud.com) and Eli (elishartung@gmail.com) if you have questions about the listed opportunities, or any questions or comments about BSA.

PAPERS TO READ FOR FUTURE LEADERS

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

- Allen, K., J. Reardon, Y. Lu, et al. 2022. Towards improving peer review: Crowd-sourced insights from Twitter. *Journal of University Teaching & Learning Practice* 19.
- Ålund, M., N. Emery, B. J. Jarrett, et al. 2020. Academic ecosystems must evolve to support a sustainable postdoc workforce. *Nature Ecology & Evolution* 13: 1-5.
- Asai, D. 2020. Race Matters. *Cell* 181: 754-757.
- Baker, K., M. P. Eichhorn, and M. Griffiths. 2019. Decolonizing field ecology. *Biotropica* 51: 288–292.
- Brown, N., and J. Leigh. 2020. Ableism in Academia: Theorising experiences of disabilities and chronic illnesses in higher education. London: UCL Press. DOI: https://doi.org/10.14324/111.9781787354975.
- Caviglia-Harris, J., K. E. Hodges, B. Helmuth, et al. 2021. The six dimensions of collective leadership that advance sustainability objectives: rethinking what it means to be an academic leader. *Ecology and Society* 26: 9.
- Chaudhury, A., and S. Colla. 2021. Next steps on dismantling discrimination: Lessons from ecology and conservation science. *Conservation Letters* 14: e12774.
- Chaudhary, V. B., and A. A. Berhe. 2020. Ten simple rules for building an antiracist lab. *PLoS Computational Biology* 16: e1008210.
- Claire Demery, A. J., and M. A. Pipkin. 2021. Safe fieldwork strategies for at-risk individuals, their supervisors and institutions. *Nature Ecology & Evolution* 5: 5-9.
- Cooper, K. M., A. J. J. Auerbach, J. D. Bader, et al. 2020. Fourteen recommendations to create a more inclusive environment for LGBTQ+ individuals in academic biology. *CBE - Life Science Education* 19:es6: 1-18.
- Cronin, M. R., S. H. Alonzo, S. K. Adamczak, et al. 2021. Anti-racist interventions to transform ecology, evolution and conservation biology departments. *Nature Ecology & Evolution* 5: 1213–1223.

- Dewa, C. S., K. Nieuwenhuijsen, K. J. Holmes-Sullivan, et al. 2020. Introducing plant biology graduate students to a culture of mental well-being. *Plant Direct* 4: e00211.
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- Emery, N. C., E. K. Bledsoe, A. O. Halsey, et al. 2020. Cultivating inclusive instructional and research environments in ecology and evolutionary science. *Ecology and Evolution* 11: 1480-1491.
- Gewin, V. 2021. How to include Indigenous researchers and their knowledge. Nature 589: 315-317.
- Gin, L. E., N. J. Wiesenthal, I. Ferreira, and K. M. Cooper. 2021. PhDepression: Examining how graduate research and teaching affect depression in life sciences PhD students. *CBE—Life Sciences Education* 20.
- 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.
- Herz, N., O. Dan, N. Censor, et al. 2020. Opinion: Authors overestimate their contribution to scientific work, demonstrating a strong bias. *PNAS USA* 117: 6282–6285.
- Huyck, J. J., K. L. Anbuhl, B. N. Buran, et al. 2021. Supporting Equity and Inclusion of Deaf and Hard-of-Hearing Individuals in Professional Organizations. *Frontiers in Education* DOI: https://doi.org/10.3389/feduc.2021.755457.
- MacKenzie, C. M., S. Kuebbing, R. S. Barak, et al. 2019. We do not want to "cure plant blindness" we want to grow plant love. *Plants, People, Planet* 1: 139-141.
- Maestre, F. T. 2019. Ten simple rules towards healthier research labs. *PLoS Computational Biology* 15: e1006914.
- McDaniel, S. F. 2021. Bryophytes are not early diverging land plants. *New Phytologist* 230: 1300-1304.
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- Nocco, M. A., B. M. McGill, C. M. MacKenzie, et al. 2021. Mentorship, equity, and research productivity: lessons from a pandemic. *Biological Conservation* 255: 108966.
- Parsley, K. M. 2020. Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet* 2: 598-601.
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- Ramírez-Castañeda, V., E. P. Westeen, J. Frederick, et al. 2022. A set of principles and practical suggestions for equitable fieldwork in biology. *Proceedings of the National Academy of Sciences* 119: e2122667119.
- Schell, C. J., C. Guy, D. S. Shelton, et al. 2020. Recreating Wakanda by promoting Black excellence in ecology and evolution. *Nature Ecology & Evolution* 4: 1285-1287.
- Simoneschi, D. 2021. We need to improve the welfare of life science trainees. *PNAS* 118: e2024143118.
- Tilghman, S., B. Alberts, D. Colón-Ramos et al. 2021. Concrete steps to diversify the scientific workforce. *Science* 372: 133–135.
- Tseng, M., R. W. El-Sabaawi, M. B. Kantar, et al. Strategies and support for Black, Indigenous, and people of colour in ecology and evolutionary biology. *Nature Ecology & Evolution* 4: 1288–1290.
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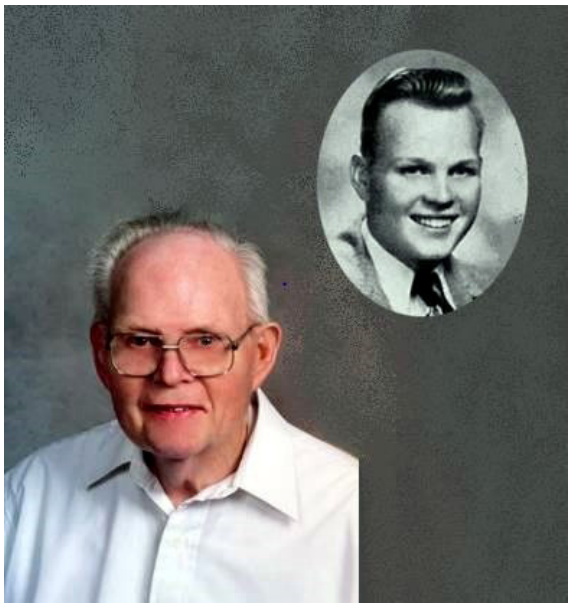
ANNOUNCEMENTS

IN MEMORIAM



NELS RONALD LERSTEN (1932–2023)

To lose a friend and colleague like Nels is never easy. However, good memories have a way of lessening the loss. That is how I remember Nels. He joined the Iowa State University Botany & Plant Pathology Department as an assistant professor in the early 1960s after obtaining his PhD at UC-Berkeley under the mentorship of Professor Adriance S. Foster, a renowned, published plant anatomist, and a past president (1954) of BSA. Nels was hired to eventually replace Professor John E. Sass, famed author of *Botanical Microtechnique*. I met Nels when I joined the Department as a two-year postdoctoral fellow, and then became a faculty member in 1966. We quickly became friends and launched into joint research projects related to sporogenesis, bacterial leaf nodules, crystals, and other topics as well. We jointly published our first of 17 papers (1966–2011) together on *Riccardia pinguis* in *AJB* in 1966.

Nels was a fountain of information, exacting in his research work and teaching, and an excellent writer that made him a perfect fit to be Editor-in-Chief of *AJB* (1990–1994). Our offices and labs were next to each other, and our graduate students took our classes and socialized together. He and I went camping and on field trips, and we played many games of hand- and racquet-ball. He was usually the better player! We and our graduate students attended many BSA meetings, and we even roomed together at a few of them. Above all, Nels was a kind, compassionate, supportive, and a "forever" friend. In retirement we had lunch together periodically, reminiscing about our earlier lives, joking about funny instances we shared, and yes, talking about our past research endeavors. Now he is at peace with his wife, and he will stay in my thoughts (and those of many others) until I see him again.

A friend and colleague, Harry T. (Jack) Horner, University Professor Emeritus

Below is an excerpt from Dr. Lersten's official obituary:

Dr. Nels Ronald Lersten passed away on Thursday, December 28, 2023, at the age of 91. He took his last breath at MorningStar Assisted Living and Memory Care in West Des Moines, IA. He had family bedside upon his death.

Nels was born in the southside of Chicago, Ill on August 6, 1932. He was the first born of Swedish immigrants Anders Einar and Elvira Maria (Bloom) Lersten. He grew up in and around the Swedish community of Chicago. He graduated from Harper High School in Chicago in 1949 at the age of 16. Nels attended the local "trolley-car" junior college until he turned 18 years old and joined the United States Coast Guard. He spent 3 years on active duty, first being stationed in Japan patrolling United States interests in the Pacific Ocean. He was then selected to become a sonar specialist and receive additional training in San Diego, CA. After this training he was transferred to the Aleutian Islands in Alaska, where he was involved in chasing down Russian submarines. Upon fulfilling his Coast Guard commitment, he returned to Chicago and enrolled at the University of Chicago where he earned his undergraduate degree (BS) in Biology and his master's degree in Botany. Nels continued his education by earning his PhD in Botany at the University of California – Berkeley in 1963.

His first job offer was at Iowa State University, Ames, Iowa, where he accepted an assistant teaching position in the Botany Department. Nels told everyone he was only staying for a couple of years, but as it turned out, he became a full professor at ISU and taught for 35 years until retiring in 1998.

Nels met Patricia Brady in 1955 while out dancing in Chicago and they married on June 14, 1958. They were married for 61 years until Pat's death in 2019. The couple was blessed with 3 children (Sam, Andrew and Julie) during the marriage. Pat was a devoted spouse and supported Nels throughout his career and they made a strong and loving team together.

Nels enjoyed a wonderful education career, which included becoming one of the first users of the electron microscope for research at ISU, taking the family to London, England for his one- year sabbatical at the Royal Kew Gardens and speaking at many Botany Conferences around North America and Europe. He became the editor of the *Proceedings of the Iowa Academy of Science* and was the editor-in-chief of the *American Journal of Botany* (1983-87) *[Ed note: 1990–1994]*. He also held various leadership roles within the Botanical Society of America and earned their prestigious Merit Award. Nels published over 120 articles and authored several books. In 2008, he published "Flowering Plant Embryology," which was his most read book and continues to be used today by Colleges and Universities for their Botany curriculum around the country. His children were always more impressed that he also wrote the section entitled "LEAF" in the World Book Encyclopedia. Upon his retirement in 1998, Nels earned the title of Professor Emeritus from Iowa State University. He was considered one of the world's pre-eminent plant anatomy experts at the time.

Nels loved the outdoors. He was always at his happiest when exploring nature. Travel was important to Nels as he would take the family on camping trips in their VW Camper Van for the last 6 weeks of every summer as the kids were growing up. He would always plan the trips around one of his speaking

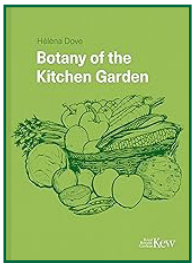
engagements, alternating throughout the Western and Eastern USA and Canada. Many great memories were created from these trips. Nels was known to stop in remote areas, grab his collection bag and trek into the forest for hours at a time. He would eventually return and emerge with a big smile, sharing tales of his new plant findings with the family, who were still either reading or sleeping by the side of the road in their VW camper van.

He was a kind and gentle soul who volunteered for many years at Beloit of Ames. He helped support multiple programs there that impacted troubled youth. Iowa Governor Terry Branstad honored him for his extensive volunteering efforts. Nels was a passionate game player and loved to play card games, poker, Scrabble and Cribbage. He once won the title of best Cribbage player in Iowa at the Iowa State Fair. He also loved to play pool and won the Windsor Oaks championship several times. Nels loved to use big words in his conversations or unique words that his family didn't know the meaning of—he would say to look it up, and of course, it was the perfect word to use. Nels loved to spend time walking in nature, he would walk twice a day at local parks in Ames even when he was in his 90s.

BOOK REVIEWS

Botany of the Kitchen Garden: The Science and Horticulture of Our Favourite Crops

Hélèna Dove
2023. ISBN: 978-1-84246-783-1
US$30 (Hardcover); 160 pp.
Kew Publishing Royal Botanical Gardens, Kew, Richmond, UK



Hélèna Dove's *Botany of the Kitchen: The Science and Horticulture of Our Favourite Crops* will delight readers with its botanical and horticultural descriptions of some of our most commonly grown and consumed fruits and vegetables. For those who are not in the know, she reminds us that the plants we eat and grow in our gardens "have wild ancestors, some of which can still be found today and some, sadly, which can't" (p. 10). Through cultivation and breeding, many of these wild plants have developed into the cultivars we now know so well, bred for traits such as sweetness or seedlessness. In many cases, Dove notes, some plants' natural defenses have been bred out of them. Dove hopes it might be possible to breed this lost resilience back into the plants we grow if we learn about how their wild relatives thrive in their natural environments. This knowledge can lend itself to establishing healthier ecosystems with growers depending less on chemicals to grow hardy and healthy crops (p. 10).

There are 52 plant entries in *Botany*, each offering a brief summary of the plants' botanical and cultivation history, physiology, growing habits, and their varieties. In each entry, Dove drives home the importance of learning the horticulture and science of the vegetables and fruits we love to grow and consume. She encourages readers to understand how a plant's botanical history bears on its botanical present, and how this knowledge can be used to ensure its future. Knowing the science behind why plants behave and adapt as they do can encourage the use of horticultural techniques that will grow the sweetest fruit, graft the best tomatoes, or produce the richest compost.

Botany encourages gardeners to use botanical and horticultural language to talk about the crops we grow: "In most vegetable and gardening texts, vegetables are referred to by their common names—carrots, apples and tomatoes, for example" (p. 16). Scientific names can often paint a fuller picture of the vegetables we grow. The carrot, for instance, is also called an "umbellifer," denoting that it belongs to the Umbelliferae family. The flowers of the plants in this family (parsley, parsnips, and carrots) share the same umbrella shape—an umbel. It is a biennial tap root with origins in Central Asia and the Middle East, and it was not always orange. This eastern carrot was once white, and "a sudden mutation in Afghanistan," it was thought, "led to purple carrots, starting with a white inner core and purple skin," which was "then bred into a fully purple carrot" (p. 82). The orange carrot we know now, the western carrot, results from breeding the wild white carrot into a carrot with yellow flesh. Over time, breeding created the sweet orange carrot, now an important economic crop.

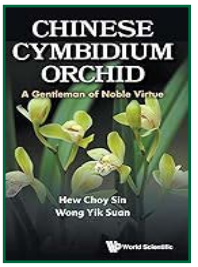
Each entry also comes replete with distinct illustrations that aid the reader in identifying various plant parts. The tiny white lines we see on carrots, for instance, are their lateral root scars. The husk that protects the tomatillo is its dried calyx. We eat the petioles of the celery and the hypocotyl of the radish. We scoop out the mesocarp of the squash to puree it for soup. The tiny hair-like strands sometimes spied on the raspberry are the remains of the pistil, the female organs of its flower. The drawings show how a plant's flower becomes its fruit and how to recognize what remains of a plant's stalk, stem, and flower. *Botany* also includes some color photographs, which add color to the green and black ink that dons the pages of the book. Together, both are tools that encourage gardeners, from novice to expert, to become more comfortable with using the language of botany to describe the plants they grow and the environs they inhabit.

Interspersed throughout *Botany* are ten short, two-page primers on various horticultural techniques. Each title begins with "The botany of…" and focuses on how, for example, to sow and save seeds, how to propagate and graft plants, or how to force crops or thin fruit trees. In "The botany of composting," for example, gardeners learn the science behind how their compost piles work. As saprophytic consumers, woodlice and brandling worms are the first to show up in the heap. They feed solely on dead plant material, decomposing leaves and branches to make food for the secondary consumers. These smaller micro-organisms (bacteria, fungi and the nonmotile actinomycetes) make a meal from the waste of the woodlice and worms, breaking this down into even smaller bits in a process that releases inorganic salts, such as potassium sulphate and ammonium nitrate, to name a few.

Botany reminds of us of the importance of knowing intimately the origins, physiology, structure, genetics, and ecology of the vegetables and fruits we grow in our gardens. For those of you who have a strong natural sense of the science of plants, Dove's *Botany* will not only shore up your intuitive sense of botany and horticulture but also teach you how to grow vigorous crops, prune and train your plants, and produce cultivars that are resilient enough to stave off pests. At 6.5 by 8.75 inches, *Botany* will fit snugly among the gardener's cookbooks and is a welcome addition to the kitchen.

--Rachel Burgess, Independent Scholar, Rochester, NY 14606; rachel.burgess.ph.d@gmail.com

Chinese Cymbidium Orchid, A Gentleman of Noble Virtue



Hew Choy Sin and Wong Yik Suan.
2024; ISBN 979811263378 (ebook), 979811263385 (ebook other), 979811263361 (hard-cover) $78; 159 pp.
World Scientific Publishing Co. Pte., Singapore

Over the years, I saw Chinese cymbidiums, including an award-winning plant at a show in Chongqing, China that was so valuable that it was under 24-hour armed guard. I also saw their paintings (both recent and old, original and copies) in the United States, Singapore, Taiwan, and China. I always wanted to learn more about them. Now I can do that by reading this book.

Lan (Chinese cymbidiums) had an appeal and meaning symbolizing integrity, modesty, elegance, purity, and nobility in ancient China. Confucius referred to *lan* as "Gentleman of Noble Virtue." An early description of Chinese orchids or cymbidiums was in 900 AD in *Yong Lan* (p. 8). Another mention of *lan* in China was as early as the spring of 770-476 BC (p. 3). Two other Chinese classic texts that mention *lan* are:

- Shi-Jing (*The Classics of Poetry* or *The Book of Songs*), the earliest collection of Chinese poetry, which dates to 11th-7th century BC.
- *Li-Ji* (*The book of Rites*), which was published in 206 BC–25 AD. It refers to *ni*, which is actually *Spiranthes sinensis,* as well as *chien* and *lan*, both of which were loose references to fragrant plants.

The use of ni, chien, and lan in Li-Ji created confusion regarding the dates in which Cymbidiums cultivation started in China. This book refers to the confusion and explains the reasons for it. There is much more to learn about the history of lan and Cymbidium orchids in China from the well-written and extensively referenced first chapter (also see Chen and Tang, 1982). Appreciation and cultivation of orchids in China (Hew, 2001) have a long history. Their appreciation was influenced by Confucianism, Buddhism and Taoism. They became part of the culture and subjects for writers, poets, painters, and calligraphers as far back as 1200–1700. Interesting details and information about the cultural history of *Cymbidium* in China open the second chapter, which includes translations of ancient poems.

A good part of the second chapter is devoted to details about ancient Chinese paintings of cymbidiums, some of which date to about 1100 AD. A number of reproductions are included in the book. Most are printed well, but two to three are a bit dark. Lists of painters, biographies, and even photographs of sculptures that depict artists are included. Reading this part of the book is both enjoyable and instructive, but somewhat slow due to the inclusion of dates (which is both desirable and necessary), Chinese characters (which I skipped), and names (which are unfamiliar).

Calligraphy is often included in Chinese *Cymbidium* paintings. Messages conveyed by the calligraphy are intended to complement the painting. They can be poems, excerpts from literature, words of praise, or even political statements. Paintings of *lan* on fans, bottles, embroidery, and even doors contain calligraphy. Postage stamps issued in 1988 depict four cymbidiums and include calligraphy. Examples of paintings that contain calligraphy are presented and discussed on pages 44-49 of the second chapter. The

chapter concludes with examples of *lan* in Chinese culture, symbolism, and the naming of girls (*mei lan*, beautiful *lan*, is an example). Altogether, the second chapter provides an excellent discussion of *lan* in Chinese culture, mostly ancient, but also current.

Cymbidium goeringi, C. sinense, C. ensifolium, C. faberi, and *C. kanran* are described in the context of modern taxonomy in the third chapter. Four of these species were described and named in accordance with current taxonomic rules by western taxonomists who did not assign to three them specific epithets that celebrate or even bear any relationship to their ancient Chinese heritage. Only one name of the four refers to China. Because of the insensitive naming of these species by Western taxonomists, the combination in this book of their Chinese history with modern taxonomy is good to have.

The type specimen of *C. goeringii*, the noble orchid and one of the earliest known Chinese cymbidiums, was collected in Japan. It is named for the German-Dutch botanist, chemist, and plant collector, Phillip Friedrich Wilhelm Goering (1809–1876) because it was described by Gustav Reichenbach *filius* (1823–1889) in 1852 in Germany. Robert Allen Rolfe (1885–1921), founder of the *Orchid Review* in the UK, the oldest existing orchid magazine, named *C. faberi* for the German plant collector Ernst Faber (1839–1899). This species was documented as far back as 1796. It bears nine flowers per inflorescence. Therefore, its old Chinese name is *Nine Children LANS.*

Cymbidium sinense (G. Jackson ex H. C. Andrews) Wildenow and *C. ensifolium* (L) Swartz, two species that were popular in ancient China, are more aptly named despite being described in the West. The *Cold Lan* (because it flowers in a cold season), *C. kanran* was named by the "Linnaeus of Japan," Tomitaro Makino (1862–1957), in 1902. He combined *kan* (cold in Japanese) and *ran* (orchid in Japanese) in its specific epithet. Another Japanese name of *C. kanran* is *Syun ran* because it also flowers when it is warm in the spring. It was brought into cultivation 2500 years ago.

Each of these species has several forms and varieties. Descriptions and illustrations of these Chinese cymbidiums (pp. 53–86) complete this chapter and make it a well-rounded and informative modern taxonomic and historical treatment.

Chapter 4 deals with the biology of Chinese cymbidiums and opens by stating that "...appreciation of Chinese cymbidiums can be summarized in four words '*Scent, Colour, Form, and Charm*'" because Chinese cymbidiums excel in leaf and flower structure, color, form, beauty, and scent. These characteristics distinguish them from other plants, as poetically noted by Wang Gui Xue in his book, *Wang Shi Lan Pu* published in 1247 (Hew, 2001), during the Song dynasty (960–1279):

Bamboo has integrity but is short of flowers.

Mei [plum blossoms, *Prunus mume*] *has flowers but is short of leaves during flowering time*

Pine has leaves when it flowers but is short of fragrance

Orchid (*Cymbidium*) *has leaves, flowers, and fragrance all at the same time.*

The biology of Chinese cymbidiums is similar to that of other orchids and *Cymbidium* species, but there are differences. For example, their (1) pseudobulbs tend to be shorter, (2) roots are fleshy unlike those of other terrestrial orchids, (3) flowers are noticeably scented

even if scent intensities may vary (Zhang et al., 2014), (4) leaves can be variegated (or plants are selected for variegation more frequently), and (5) leaf and stomata structure is similar to those of other monocotyledonous plants, but even within one and the same species there are differences in length and color. The biological characteristics of Chinese cymbidiums are described, discussed and, explained well in this chapter (pp. 87–120).

Surprisingly there is no known evidence that the ancient Chinese propagated cymbidiums from seeds. It is not even clear if the ancient Chinese recognized orchid seeds for what they were. If they exist, ancient writings, paintings, or drawings of seeds are yet to be discovered. I keep hoping that a careful reading of ancient Chinese books on orchids will find writings on seeds. This chapter deals with what is known at present about fruits (but refers to them as pods on pp 108 and 109; they are capsules), seeds, and seed germination of Chinese cymbidiums. Clonal propagation of Chinese cymbidiums in the past was by division of plants. This is still practiced at present, and so are modern propagation methods. All current methods of Chinese *Cymbidium* propagation are described in detail in this book.

Ancient Chinese cymbidium growers had no means of learning about orchid mycorrhiza. However, they were perceptive enough to realize that there are components in the natural substrates where they grow that facilitate and/or improve growth. That is why there are suggestions in the ancient literature that when collecting Chinese orchids from the wild, one should also collect substrate debris along with the plants because this was important for the establishment of the collected plants (for details about ancient cultivation methods. see Hew [2001]). Chinese cymbidiums are cultivated extensively at present by modern methods. These methods as well as pests and diseases are illustrated and discussed in Chapter 5 (pp. 121–142). Anyone interested in growing Chinese cymbidiums will find enough information in this chapter.

A short chapter (6) about the prospects of Chinese cymbidiums concludes the book. There are also an extensive list of references and an index.

I have two criticisms about this book. One, probably the authors' responsibility, is that references 49–89 (pp. 152–154) are listed only in Chinese. It would have been useful to also present English translations. This would have allowed readers who do not read Chinese to obtain an idea about what these references deal with. The publisher is responsible for the second. Page size is 15 cm × 23 cm. This small size forces reduced images, especially when there are several of them (p. 101 has 18), resulting in unclear images and hard-to-discern details. A bigger page size (standard US letter size, 21.6 cm × 27.9 cm, for example) and fewer images per page would have allowed for larger and clearer illustrations.

As a result of visiting Singapore almost annually for many years and spending long periods there, as well as paying several visits to China (starting in 1979) and Taiwan, I developed an interest in Chinese cymbidiums. It was not enough to get me to grow even a single plant or carry out research about them, but it was sufficient to want me to learn more. This book did enable me to do so. I am sure that anyone else who will read it will also become better informed about these beautiful and fascinating cymbidiums. Despite its exorbitant price (determined by the publisher, not the authors), this book should find its way to private and institutional libraries.

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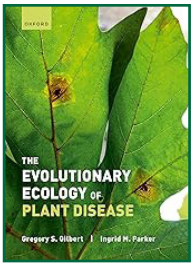
[Reviewer's Disclosure: Professor Choy Sin Hew (world class orchid scientist based in Singapore, and laureate of the 1997 Singapore National Science Award, the highest honor for a research scientist in Singapore), and his wife, Senior (accomplished and resourceful) Librarian Yik Suan Wong, both now retired from the National University of Singapore (where I spent long periods since 1969), have been close friends for about 50 years. I saw this book as published and in manuscript. Another old friend (30 years), the noted Japanese orchid scientist Professor Syoichi Ichihashi (now retired) helped me by translating and explaining the nomenclature of Cymbidium kanran.*]*

The Evolutionary Ecology of Plant Disease



Gregory S. Gilbert and Ingrid M. Parker
2023. ISBN-13: 9780198797883
US$50.00 (Paperback); 336 pp.
Oxford University Press, New York, NY, USA

Fungi, bacteria, and viruses, oh my! For many seasoned and aspiring plant pathologists, Agrios' *Plant Pathology* or Westcott's *Plant Disease Handbook* were likely the first textbooks they were required to purchase and read as an introduction to the field. Although these tomes have been updated and new editions have been released, they have not been updated to include much content on the evolutionary relationships between plant microbes and their hosts, which is an area of plant disease ecology research that has made significant strides in the last few decades and could benefit from a synthesis. Enter *The Evolutionary Ecology of Plant Disease*, a new primer on the symbiotic relationships between plants and microbes. This novel text was written by Drs. Gregory Gilbert and Ingrid Parker, who are ecologists and professors at the University of California Santa Cruz. The book is organized into 17 chapters broken into two parts: (1) Plant Pathogens and Disease and (2) Evolutionary Ecology of Plant Pathogen Symbioses. It also includes a detailed preface with summary of the chapters and epilogue with a summary of compelling future research trajectories in evolutionary ecology of plant disease. The handy index in the back allows readers to easily locate keywords and species mentioned in the text, and each chapter includes a references section with recommendations for further study of a particular topic.

"Part 1: Plant Pathogens and Disease" is comprised of nine chapters that focus on

the biology and ecology of plant pathogens. Chapter 1, "Thinking Like a Plant Disease Ecologist," is essentially "Plant Disease: 101" with a definition of plant disease and evolutionary ecology, as well as a summary of epidemiology, the disease triangle, Koch's postulates, symbioses, and pathogen life history strategies. The chapter also delves into how to calculate how many plant pathogens there may be, globally, although the discussion is primarily focused on how difficult that actually is to estimate without providing an overall guess-timate. The second chapter provides an introduction to plants, particularly on their physiology, reproduction, hormones, and taxonomy. The chapter is not inclusive of everything one should know about plants, but provides the highlight reel of the most important factors that impact plant relationships with pathogens. Chapters 3–7 are focused on introducing the different categories of plant pathogens, including fungi, oomycetes, bacteria, viruses, and macroparasites, such as nematodes and parasitic plants. Some of the chapters have more information than others, but they all generally cover the growth and reproduction or replication of these pathogens, with some chapters considering how the pathogens are classified by taxa and related to other groups (e.g., did you know that fungi are more closely related to humans than oomycetes?). Chapter 8 introduces types of plant diseases, including foliar, developmental, root and vascular, woody stem, and reproductive structure diseases. The chapter provides a helpful table of the plant disease classifications based on their characteristics, with further details in the text. The last chapter in Part 1 summarizes how to do disease ecology, ranging from visual assessments of signs and symptoms to culture- and DNA-based approaches. This discussion of disease intensity and impact on host plant species and abundance and distribution of pathogens within an environment is supplemented with colorful figures that describe techniques disease ecologists and plant pathologists have commonly used in the past and present to measure these variables.

"Part 2: Evolutionary Ecology of Plant Pathogen Symbioses" contains eight chapters that take the basics provided in Part 1 and build to detail the relationships between plants and their pathogens at different scales. Chapter 10, "Population Ecology of Plant Disease," provides an introduction or refresher on population model terminology, such as carrying capacity, exponential growth, and logistic growth, how diseases have cycles with one or more host plants to which they have to disperse, and generally how plants and pathogens shape each other's populations over time. Chapter 11 focuses more on the dispersal and spatial ecology of plant pathogens, while Chapter 12 delves into the physiology and genetics of plants, their defenses against pathogens, and how plants and pathogens communicate with each other through chemical signaling. Chapter 13 begins with a refresher on genetic drift and natural selection, but slowly builds in how evolutionary history between plants and pathogens drives pathogen virulence, host resistance, host range, and coevolution. The next two chapters discuss pathogen diversity, competition, and symbioses within plant communities, including beneficial fungi, such as mycorrhizae. The last two chapters focus on global change and disease management (e.g., biological, chemical, and cultural controls), which are important topics to cover when discussing plant pathogens, given the impacts of factors like invasive species, pollution, global climate change, and landscape fragmentation on pathogen abundance and spread, and how that affects subsequent management.

Overall, *The Evolutionary Ecology of Plant Disease* contains a basic introduction to microscopic and macroscopic plant pathogens, followed by discussion of the theoretical frameworks of evolutionary ecology between plants and their microbes. Although the book does not go into as much depth about the basic biology of plant pathogens as Agrios' *Plant Pathology*, Gilbert and Parker's discussion of population, community, and spatial ecology of plant disease, evolution of plant disease, global change, and disease management makes this a unique and suitable read for advanced undergraduate and graduate students in botany, ecology, evolution, microbiology plant pathology, and forestry, as well as plant pathology practitioners and researchers. Although most keywords are bolded and defined, some of the complex terminology and discussion makes the book better-suited for an advanced audience than introductory-level undergraduates or those who are new to evolutionary concepts. The structure of the book and short primers on analytical techniques make it an appropriate reference for courses with or without labs or even for individuals who want a quick summary of long-standing and new techniques in the fields of plant pathology and evolutionary ecology.

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Flora of Oregon Volume 2: Dicots A–F

Stephen C. Meyers, et al. (eds.)
2020. ISBN 978-1-889878-61-4
US$85.00 (Hardcover); 880 pp.
BRIT Press

This is the second volume in the three-volume work covering the diverse flora of the state of Oregon. The first volume, published in 2015, covered lycophytes, ferns, and monocots. The present volume covers the dicots in families A–F. This includes many large and important families such as the Asteraceae, Brassicaceae, and Fabaceae. In total, 39 families are covered, with 1668 taxa fully treated.

The book opens with an introduction covering the scope of the flora, including a nice table listing the number of native and exotic taxa treated, how many are endemic to Oregon, and which families have the highest diversity, among other metrics. I liked that the Introduction also included an explanation of abbreviations and symbols, something I haven't seen in many other floras. I'm sure that people who aren't professional botanists will appreciate this, as many people may not know what "spp." and "*s.l.*" mean. Following the Introduction is a nice section on landscaping with native Oregon plants. Oregon is a topographically and climatologically diverse state, and this section nicely covers what species are best suited for particular ecoregions and garden types. Further information on picking native plants for gardens is included in an appendix. I found the next section to be fascinating: Insects as Plant Taxonomists. This section covers various plant families and the insects that pollinate or feed on them. It's a very interesting read and contains many beautiful photos of insects and the plants they

utilize. There is also an appendix of native plants that attract insects and specialist solitary bee species. Lastly, there is a nice section on the importance of herbarium specimens in publishing a Flora.

After these sections, the dicot families are listed alphabetically. Older family names (e.g., Aceraceae) are listed with page or volume references to the "new" family where those species can now be found. Each family has a relatively brief description followed by a key to genera (if needed), and then the genera are alphabetically arranged. Each species account includes a description, habitat information, ecoregion range, and its provenance. Some species have further information on look-alikes, morphology, or status. A small map of the state is inserted in the corner of the description. The maps use dots for specimen localities, and the ecoregions where the plant occurs are shaded. I really liked this approach to range maps. Numerous line drawings accompany many species, and they are of good quality.

Fifty-five authors contributed treatments to this work, and each is listed under the family or genera they wrote. The keys I examined and/or tried out worked well, and I didn't notice any glaring errors. After the treatments there is a large glossary with many illustrations, references, and an appendix on misapplied names.

The book itself is of high quality and not too heavy; it could be brought along in a backpack. I'm sure the third volume will be just as good in production and content, and the authors and editors should be proud of this wonderful work.

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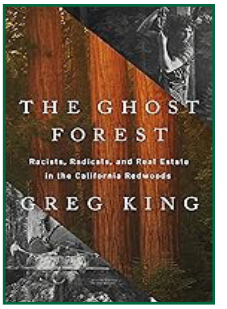
The Ghost Forest: Racists, Radicals, and Real Estate in the California Redwoods



Greg King
2023; ISBN 9781541768673
US$32.00 ((Hardcover), 457 pp.
Public Affairs (Hachette Book Group), New York

You may recall Richard Powers' 2018 Pulitzer Prize winning novel, *The Overstory*, where Humboldt Timber are the bad guys and Nick and Sylvia protest logging by sitting-in on a platform hundreds of feet up in a redwood. Author Greg King, along with Mary Beth Nealing, were the real tree sitters in the first All Species Grove protest in 1987 in Humboldt County, California. In *The Ghost Forest*, King, a journalist/activist, provides a well-documented history of the California Redwood forest from the time of statehood to the present.

The book is divided into five parts. King begins with a recollection of playing a sort of "king of the hill" with a bunch of friends on a redwood stump in a friend's backyard on his 5th birthday. He was thrown off, but he doesn't remember much else. The stump is still there, 10 feet above ground and 20 feet across, in his hometown of Guerneville, Sonoma County, California. King is a fourth-generation resident whose great-grandfather emigrated from Canada with four brothers in 1873 to log the redwoods—three years after "Stumptown" was renamed Guerneville. This opens the first part of the book, "Stumps," whose 16 chapters introduce the biology of redwoods and the history of logging along the Russian River in Sonoma County. Prior to 1850 about 150,000 acres of redwoods stood in Sonoma County. Most of this was already gone by the time King's grandfather was born in 1903. This loss includes some of the largest trees ever known. The section ends with King's tree sit-in in September 1987.

Part Two, "Empire," contains an eight-chapter account of California's redwood forest ownership—originally nearly 1.5 million acres of publicly owned timber. Statehood, in 1850, initiated commercial logging and the transfer of forest lands from public to private hands. King quotes Pulitzer Prize–winning historian Bernard DeVoto: "…publicly owned timber passed into corporate ownership at a small fraction of its value…by fraud." Abuse began with the 1841 Preemption Act and the 1863 Homestead Act, both of which provided homesteaders with 160 acres of land. Gangs of men were employed to make claims, which were immediately transferred to middlemen working for the corporations that pooled the claims. Even so, in 1878 more than 80% of the redwood forest remained public land. The 1879 Timber and Stone Act (called by John Muir the "dust and ashes act") ensured that by the 1920s, when power saws replaced hand saws for felling, most of the timber was owned by a few competing corporations. One of these, the Little River Redwood Company, finally reached the "Crannell Giant" in 1926 and immediately cut it down. This 30-foot-diameter giant was the second largest tree ever measured, comparable to the Lindsey Creek tree, 390 feet tall with a 34-foot diameter at its base, that stood one small watershed away and was already reduced to a stump. Both produced more than a million board feet of lumber—20% more than is contained in the extant General Sherman tree. The stumps of both remain.

Part Three, "A League of their Own," documents the greatest irony of the book, of which King was entirely unaware when he began researching the redwoods. In September 2009, King met and interviewed Martin Litton, who, as director of the Sierra Club in 1960, launched the first (and only) campaign to establish a watershed-wide Redwood National Park. The previous year Litton discovered the Tall Trees Grove on Redwood Creek, and in 1963 he hosted a team from the National Geographic Society to survey the site. In July 1964, Tall Trees Grove was the 52-page cover story in the magazine—the country was excited and a park was formed 4 years later. But as Litton commented to King, it was not the park they wanted. "It was so weird and strange that Save the Redwoods League would oppose getting a new national park." This is when King realized that what he thought was a well-meaning but weak organization was something entirely different, and it resulted in a years-long deep dive into the archives of the League in Berkeley's Bancroft Library. The League didn't just defer to the lumbermen: it was created, owned, and controlled by these firms. They also pioneered the tools of public relations false fronts and "greenwashing" to control public opinion. "Within such a system it was imperative that the redwoods be saved not from the saws but from preservation." The 28 chapters of Part Three documents how the 1.2 million acres of Redwoods still standing in 1917 were reduced to less than 120,000 acres today, much of it degraded. And to make it worse, by 1990 the total cost of Redwood National Park reached $1.6 billion: the most expensive in U.S. history as the result of industry "triple dipping" to maximize profits by driving up sales costs to sell back to the government land that was initially stolen.

Part Four, "The Empire Strikes Back," returns to the Old Species Grove tree sit-in that ended Part One and documents King and Nearing's subsequent arrests and arraignments. King and Nearing were members of the "Earth First" movement, which spent the next decade protesting clear-cutting in the redwoods, especially by the Maxxam Corporation. The protests were designed to garner public support for preservation and enlargement of the newly established Redwoods National Park – State Parks, but government and industry spun the media, blocked legislation,

and harassed the environmental protesters, ultimately leading to a 1990 car bombing of two of the leaders, Judi Bari and Darryl Cherney. Both were injured and survived, and 12 years later a federal jury finally found six of seven FBI and Oakland Police defendants liable. The jury awarded $4.4 million in compensatory and punitive damages. Bari died of cancer in 1997, but Darryl used her filmed deposition in a 2012 documentary "Who Bombed Judi Bari" (on YouTube). The final part of the book is a single short chapter consisting mostly of the letter written to King by his mother when he was six and she was diagnosed with terminal cancer. She lived another 22 years and King recalls "her fiery resolve railing against injustice." It is a special acknowledgement chapter before the Acknowledgments.

The book is well-indexed and has an extensive bibliography of archival collections, interviews and oral histories, legal and public documents (including testimony), newspapers, periodicals and trade publications, published sources, and unpublished theses and papers. In the middle of the book is a section of 21 color and black-and-white images that provides historical documentation, especially of the protest movement. Anyone interested in environmental history should have this on their bookshelf. It is appropriate outside reading for any introductory biology course.

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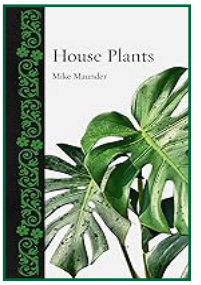
House Plants

Mike Maunder
2022; ISBN: 978-1-78914-543-4
US$23.60 ((Hardcover); 256 pp.
Reaktion Books LTD



Post-pandemic, Plants are Popular!

We are experiencing a house plant renaissance, with people recently confined to home for an extended period, practicing social distancing and spending more time alone or with fewer people, to prevent the spread of Covid. Many have realized that bringing plants into one's home is not only fun and interesting, but also pleasant and relaxing. The time is perfect for the launch of this new book that may be enjoyed by anyone who likes plants, including botanists and professional horticulturalists.

I've had the pleasure of reading through (and now reviewing) *House Plants* by Mike Maunder. One of a botanical series published by Reaktion Books, it is one of the few in the series that considers a great variety of plants, since most focus on a particular kind, family, or genus of plants. I have found this book easy to read and relaxed but compelling, as each turn of the page reveals unknown connections and histories of familiar plants that (I must admit) I have always taken for granted.

Maunder gives a global perspective as he reveals the history of many well-loved and common house plants. For centuries, people have cultivated wild-collected plants from around the world; consequently, horticulturists had to figure out how to grow and propagate species collected in distant lands. When tropical plants were and are carried to temperate climates, they must be overwintered in those frozen latitudes with protection indoors or in protective sheds.

Early greenhouses (glasshouses) were heated by burning coals in a barrow wheeled around the conservatory! Although still a challenge, keeping plants warm in the winter is easier nowadays with heating systems, and such places provide a very welcome respite from the cold and dry environment indoors when it is snowing outside. In fact, such experiences set me on my botanical course as an undergraduate student at the University of Michigan—a digression into the personal here.

Not only did horticulturists figure out how to grow these imported plants, but they modified them using various techniques: hybridization, radiation to engender mutations, and somaclonal variation (where novel mutations are induced by micropropagation). From such manipulations, desirable characteristics have been selected. Thanks to artificial selection we have beautiful modifications of flower colors and shapes, and leaf size and pattern. Thanks to micropropagation, we now have previously very rare and special plants (such as moth orchids, *Phalaenopsis*) now offered in many colors and patterns at grocery stores at affordable prices. This technique is also used in conservation programs, as in the Million Orchid Project of Fairchild Tropical Botanic Garden, propagating native orchids whose populations have dwindled in nature due to over-collecting, poaching, and habitat loss. The many native orchid offspring produced are used for outplantings not only in natural areas, but in parks, in schoolyards, and on city street trees, alleviating pressure on and strengthening the remaining natural populations.

I really enjoyed learning about the origins of many common plants, such as *Kalanchoe* and *Schlumbergera* that now have varieties with many different flower colors. African violets (*Saintpaulia*) originated in Tanzania and have perhaps the longest history of intensive breeding following domestication. The many varieties available today have resulted from hybridization and subsequent selection of varieties in different parts of the world. Freesias and pelargoniums ("geraniums") came from the Cape Region of South Africa. Poinsettias hailed from Mexico, where they were developed as a horticultural crop and now are a major industry during the holiday season in North America. Caladiums, grown for their large, colorful, patterned leaves, are grown in the Lake Placid region in Central Florida. They were collected first in tropical South America in the 1700s and taken to breeders in Europe, then came back to the United States, and then to Thailand, producing many new colors and patterns of beautiful foliage.

The author points out that not only do houseplants alter the Indoor Biome, but the Urban Biome as well. They alter the ecology of a home by reducing volatile organic compounds as well as providing fresh oxygen as a byproduct of their photosynthesis. Inside and outside plants are integrated with building design, used in vertical walls and on apartment balconies. Grown in planters and in home landscapes, house plants find homes outdoors and beautify human living spaces.

Until fairly recently, it was common for desirable plants to simply be collected from their natural habitats (many bulb plants, succulents, and epiphytes [bromeliads, orchids, and ferns]), with little concern about conservation. Many of the ancestors of our favorite houseplants come from areas known as "biodiversity hotspots,"

and Maunder reviews the origins of many beautiful species and the special habitats from which they originated. The ponytail palm, *Beaucarnea recurvata*, is endemic to the dry lands in the Tehuacan Valley in Mexico. Overcollecting and urban expansion reduced wild populations by 80%, and it is categorized as critically endangered. It is now propagated in commercial nurseries in the Canary Islands, California, and Thailand, so that most plants sold today have been legally grown in nurseries. In the 1990s, I was assisting a field team studying the reproductive biology of these fascinating plants (Cardel et al., 1997), that are dioecious (separate male and female individuals, with some that apparently changing sex) and need pollinators to set seed. I am very glad to learn they are now commercially grown and widely sold.

Knowing more about many common house plants makes them all the more fascinating, and I think that people reading this book will come away with a deep appreciation for the origins and original habitats of these domesticated beings. I find the timeline at the end of the chapters an interesting review of the many stories told in the book, simply illustrating the centuries of domestication that has led to the popular plants we know and grow today.

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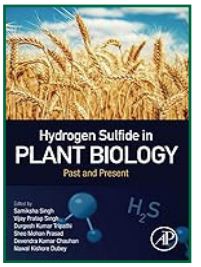
-Suzanne Koptur, Professor Emerita of Biological Sciences, Florida International University and the International Center of Tropical Botany

Hydrogen Sulfide in Plant Biology: Past and Present



Samiksha Singh et al.
2021; 978-0323858625 (paperback), 9780323858632 (e-book)
$190; 392 pp.
Academic Press

In biology, hydrogen sulfide (H_2S) is often viewed as either an environmental toxin or an exotic environmental component in the context of extremophiles, far from the gentler locales typically inhabited by plants and botanists. In the field, its rotten egg smell warns of the presence of geothermal features and potentially inhospitable environments. A dramatic example of an adaptive plant response to H_2S is given by the ʻōhiʻa tree of Hawaiʻi, which closes its stomata to avoid toxic doses of H_2S, enabling its survival during volcanic eruptions. However, this is an extreme case of a widespread phenomenon: H_2S is involved in many biological processes, including gas transfer, in all plants. At lower doses, H_2S is an important signaling molecule, along with other plant gasotransmitters including carbon monoxide, nitrogen monoxide, methane, and ethylene. In particular, H_2S is involved in responses to many different sources of stress, which is a major theme of this work.

This book is a collection of reviews by different experts on the state of knowledge about H_2S as a signaling molecule in plants. It is highly technical and is targeted at readers with a strong background in chemistry and molecular biology. Broad biological topics include the general role of H_2S as a gasotransmitter (Chapter 7), its impact on the development of different organs under stress (Chapters 5, 8), and the regulation of H_2S homeostasis (Chapter 17). H_2S is produced in the mitochondria, chloroplasts, and cytoplasm, and it is used by cells to produce cysteine.

H_2S persulfidates proteins, influencing their function and transport. It also regulates transcription, both epigenetically and via cross-talk with other signaling pathways (Chapter 9). These chapters discuss not only how H2S signaling works in intact plants, but also how exogenous H2S can be used to delay fruit ripening and senescence of cut flowers.

A particular strength of this book is its comprehensive treatment of the mechanistic aspects of different stress responses involving H_2S, including how plants respond to temperature stress (Chapter 1), oxidative stress (Chapter 3), heavy metal stress (Chapter 4), general abiotic stress (Chapter 6), salt stress (Chapter 11), drought stress (Chapter 12), and radiation stress (Chapter 14). These chapters cover how different aspects of abiotic stress impact plant growth and development, and how H_2S and other signaling molecules counteract some of the negative effects on plant function. These chapters provide many biochemical details about the biosynthesis of H2S, how it is induced, and the mechanisms by which it impacts cellular processes. Practical implications include genetic engineering of crop plants for better tolerance to warmer, drier conditions, as well as the use of H_2S to mitigate damage to tropical fruit caused by post-harvest cold storage.

The impact of H_2S is often felt in combination with other signaling molecules. For example, it regulates plant growth and fruit ripening in concert with nitric oxide (NO) and melatonin (Chapter 2). Its ability to delay post-harvest ripening appears to be related to inhibition of enzymes that loosen cell walls, as well as resistance to oxidative damage. Interaction with reactive oxygen species (ROS) is discussed in detail in Chapter 10. Although H_2S is a powerful reducing agent in its own right, its best-known ROS-scavenging activities are indirect, via its role (with NO) in upregulation of enzymes like superoxide dismutase and glutathione reductase that reduce ROS. It also works in concert with NO to regulate glutathione homeostasis, controlling the amount of reducing agents in the cell. Similarly, H2S interacts with plants' Ca^{2+}-dependent signaling system to enhance abiotic stress tolerance (Chapter 16). This effect is realized partly through persulfidation of key enzymes (preventing irreversible oxidative damage), by regulating metal-binding proteins and by helping to maintain the high K^+/Na^+ ratio inside cells even under stress conditions. The crosstalk of H2S with phytohormones in plant responses to pathogen attack (Chapter 13) and abiotic stress (Chapter 15) are also discussed. The state of knowledge on how different signaling pathways interact across a wide range of plant species is presented in meticulous detail.

This book is thorough and scholarly, with impressive coverage of the current literature. It provides an extensive review of the current state of knowledge about the biological roles of H_2S in plants. One highly useful feature is that each chapter includes a well-organized and informative table of references, each with a short summary of the major conclusions. This makes it easy to determine which references are relevant for future study of a particular topic. Despite the wealth of information presented, this book could have benefited from more editing and curation of the contents. For example, it lacks an introduction putting the work in context and describing the goals and intended audience of the book. The chapters, although most are individually very well organized, are presented apparently without thematic groupings. Some of the chapters have significant topical

overlap, and the resulting repetition detracts somewhat from the impact. Overall, this book is a valuable resource for expert readers who are seeking a comprehensive literature review and detailed analyses of specific biological pathways involving H2S.

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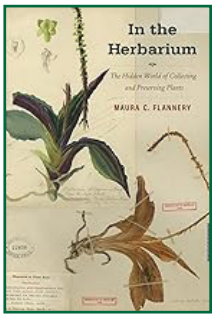
In the Herbarium: The Hidden World of Collecting and Preserving Plants

Maura C. Flannery
2023; ISBN 978-0-300-24791-6
$35.00 (Hardcover), 325 pp.
Yale University Press, New Haven, CT



For years, Maura Flannery contributed a regular column to *The American Biology Teacher*, which honed her skills in writing for a broad, biologically literate audience. This skill is essential for the success of a book devoted to collecting and preserving dead plants—what is commonly understood by the public to be the primary occupation of botanists. Besides an engaging writing style, the author must have a passion for the subject to bring it to life for a general audience. As Flannery notes in her first sentence, she was "moonstruck" on a behind-the-scenes tour of the Natural History Museum during Botany 2010 when she examined plant and seaweed specimens from the 19th century. On the one hand was the beauty of the specimens (her Historical Section presentation that year was "The Botanist as Artist"). But there was also the wealth of information on the labels and sheets that went far beyond the name of the plant and where it was collected. The passion she developed during the past dozen years, for all aspects of collecting, preserving, and utilizing plant specimens, is clear in this book.

The book begins with a case study illustrating many of the concepts and topics that will be covered in the book. Harvard botanist, Oakes Ames, and his wife, Blanche, travelled to Berlin in 1922 to meet with Rudolf Schlechter. Schlechter, like Ames, was an orchid specialist, and Schlechter's living and pressed collections at the Berlin Botanical Garden were the largest in the world. While Ames and Schlechter worked on identifications of new species, Blanche produced watercolors of each of the species Oakes would bring back to Harvard. One of the specimens, Fig. 1.1 and the color dustjacket image, illustrates all the components typically found on an Ames herbarium sheet: the actual mounted specimen, the life-size watercolor with inset floral details in various stages of dissection, a folded paper packet for smaller parts, label information for both the specimen and watercolor, and accession information. The collection note on the label indicates "From type plant *fide Schltr.* Collected in Berlin Botanic Garden by O.A." Unfortunately, the actual type specimen was lost when the Berlin Garden and Herbarium were destroyed in WWII, so the Ames specimen serves its place. A final concept illustrated by this example is that taxonomy is not static; while it was named *Microstylis philippinensis Kzl.* on the label, it is now *Malaxis dentata Ames* according to a more recent annotation on the sheet. Flannery elaborates on every component of the construction of this specimen, along with many other related topics, in subsequent chapters.

The elaboration begins with a brief history of early botany, from the Greeks to the early Italian Renaissance. The focus is on plant

identification and *materia medica* and includes establishment of early botanic gardens and documentation using dried and pressed plant collections mounted on single sheets or bound in volumes. One of the Italians Flannery discusses is Ulisse Aldrovandi, professior of Natural History at the University of Bologna in the mid-1500s. He is credited with formulating a glue for mounting specimens on sheets of paper that could be stored in the museum. His personal collection "with thousands of herbarium specimens alone" (p. 24) still exists (and according to *The Guardian* [8 Nov 2023], his 5000 sheets are currently being used as the baseline for a study of climate change in northern Italy) (Weston, 2023). This substantiates one of the modern critical uses of herbaria discussed in the final chapters.

An obvious, but overlooked, technological innovation required for herbaria—paper—is the first subject addressed in Chapter 3. A certain type of paper is required to absorb moisture during pressing, but a different type is required upon which to mount a specimen to help preserve it and allow for annotations. Printed labels and accessory illustrations required a sized surface (gelatin coating) to make it smooth and to hold pigments. The innovations in paper processing, and the printing press, allowed for the production of prints and herbals as well as for making and mounting herbarium specimens. Thus, as collecting expanded around the world, the tools necessary to process the expanding volume of plant materials became available.

Seven chapters in the middle of the book detail different phases of plant exploration, driven by personal and national motivations and values. Early European explorers were overwhelmed with the diversity of plants they encountered and collecting novelty played a part, but the primary interest for national support was the potential for economic gain and medicinal use. Even if herbarium specimens were not collected, seeds of described species could be brought back to Europe, grown out and exchanged.

Some individuals enjoyed enormous personal influence, and Flannery devotes a chapter each to two of them. The first is Hans Sloane, the English physician and naturalist who, among other things, founded the Chelsea Physic Garden and later became President of the Royal Society. His personal herbarium collection, numbering in the thousands, included specimens from more than 280 different collectors, as well as his collection of "vegetable substances" (seeds, fruits, resins, etc.) and his art collection and personal library became the basis of the British Museum; today they are divided between the Museum, the British Library, and the Natural History Museum. One of Sloane's contemporaries and correspondents was Linnaeus, best known for his systems of nomenclature and classification. Flannery provides a brief biography illuminating events influencing his life and his role as a teacher and supporter of plant explorers. Linnaeus' herbarium is the heart of the collection of the Linnean Society of London.

Later explorations tie more explicitly with imperial colonialism around the world. Nations both protected their monopolies and spread production to other colonies around the world with the aid of national gardens, such as Kew in London and the Jardin du Roi in Paris, and indigenous and/or imported workers. (The slave trade, as modern society is becoming much more aware, was intimately tied to the spread and production of economic plants and the personal and institutional fortunes that accumulated.) Flannery also devotes a chapter to changing attitudes and legal rights of indigenous peoples and their associated economically useful plants.

The chapter on evolution takes Linnaeus' type specimens and applies Darwin's recognition of the roles of variation and selection to form the basis of systematics—a new way to look at the relationships between plants. But new tools developed early in the 20th century, ecology and genetics, became exciting in their own right and traditional collecting and herbarium activities began to decline. Beginning in the 1980s, however, the role of biodiversity and the subsequent efforts to conserve it refocused the importance of herbaria to supporting these efforts. In the last two chapters, Flannery explains modern approaches to digitizing and utilizing data from herbaria and presents a broader vision of how herbaria can be used to reengage the public through an awareness of the cultural connections with plants.

This book should have very broad appeal, but my first recommendation is that it be required reading for every herbarium curator, particularly for the final chapter, "A Broader Vison: Herbaria and Culture." Yet the entire book is perfused with nuggets of information that will probably be new to even the professional reader and provides broader perspective. It will also appeal to anyone with a cultural interest in plants, whether it be growing plants, their aesthetic value, or opportunities for recreation or citizen-science.

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The Man Who Organized Nature: The Life of Linnaeus

Gunnar Broberg (Translated by Anna Paterson)
2023. ISBN 9780691213422
US$39.96 (Hardcover); 484 pp.
Princeton University Press

Who was Linnaeus? If he's included in a current introductory textbook at all, it will be only in a paragraph explaining binomial nomenclature and certainly not as the botanical hero I was introduced to by Cronquist (1961). Morton (1981) filled in the details I wanted to provide in my courses as a young instructor. Then, in 1994, Isely surprised me by referring to Linnaeus as "the scribbling Swede" who produced "…an apoplectic deluge that continued throughout his life" and that it was "because of his ingenuity, his industriousness, and his effectiveness as a PR man, that he put taxonomy into the big time, the dominant arena of biology for 100 years" (pp. 88, 90, 92). Broberg explains all.

Broberg points out that we know more about Linnaeus than any other Swede of his time—primarily because of his own paper trail. He wrote three (or was it four, five, or six?) autobiographies over the course of his life, with each resembling a complete, detailed professional C.V. (Upon his death, one of the editors of his *Vita* commented, "Linnaeus is one of those writers who never discovered the danger of superlatives… self praise is no recommendation. (P.2)." He wrote more than 70 books (with multiple extant revision manuscripts of many) and more than 176 dissertations (the equivalent of an academic paper of 10–50 pages each). Most were in Latin, but some were in Swedish. He had about 600 regular correspondents, mostly in Europe, with a total correspondence of 8000–10,000 documents (archiving is

ongoing; interestingly, there are almost no personal family papers!). There are lectures and notebooks (both his and his students). There are government papers and university documents signed by or including Linnaeus. There are secondary sources such as newspapers, legal documents, published reviews, etc. Finally, there are 10 previously published comprehensive biographies, the earliest in 1792 and most recently in 1999. Linnaeus was prolific and concerned with the preservation of his work; Broberg examined most, if not all, of this written work and incorporates a wide breadth of it in this book.

The text is divided into three parts that cover: (1) his youth, education, and major influences; (2) his professional life at the university, professional service to the government, and home life; (3) his later life at home, with students and colleagues, with friends and acquaintances, and with growing old.

Linnaeus was born May 23, 1707, the first born of a poor country minister in southern Sweden—but his father loved plants and taught Linnaeus their Latin names from youth. At nine he was sent to a boarding school where his study skills began to be honed. Forty-seven required hours a week were spent in the classroom with 17 devoted to Latin (language was not one of Linnaeus' strengths). But he was taken under the wing of Johan Rothman, who taught the natural sciences and introduced Linnaeus to sex in plants. Linnaeus also began a life-long habit of annotating the pages of books and papers and began keeping a personal notebook (The Book of Herbs) that included botanical notes from his readings and sketches and descriptions of the plants he observed. Not a scholar, Linnaeus graduated 11th of 15 students in 1727, but Rothman's private tutoring and a recommendation gained him entry to the University of Lund to study medicine. His father presented him with a folio copy of Aristotle's Historia animalium. Within four days he found a new mentor, Kilian Stobaeus, a physician and professor of Natural History who was impressed by Linnaeus' knowledge of botany and love of reading and virtually adopted him as a son with privileges to his library. Although Linnaeus transferred to Uppsala suddenly the next year, he continued corresponding with Stobaeus at least until his Lapland trip in 1732. After a difficult first year, Linnaeus, by chance, met a new mentor, the botanist Olaf Celsius, outside the Lund Botanical Garden. Linnaeus tutored private pupils and began developing a reputation as an engaging lecturer in his position as Temporary Botanical Demonstrator. Linnaeus later noted that this was the year he began writing Fundamenta Botanica and testing his ideas for a classification system. In the printed Postscript, he later wrote: "And I can assure you of this, namely that with time you [the book] will come to inhabit the palace of Botanices principum." By now his personal library contained more than 130 books in a variety of subjects but mostly medical (59), botanical (25), Materia medica (11), and a copy of his Vita Caroli Linnaei.

Linnaeus' 1732 journey through Lapland, sponsored by the Royal Society of Sciences in Uppsala, was as significant to him—to his medical training as well as his natural history—as the Beagle Voyage was to Darwin. For the rest of his life, and in every way, "Linnaeus was always unequivocally positive about the Sami [Laplanders]" (p. 300). For instance, the year following his return, in a lecture on the animal kingdom, Linnaeus recognized four geographic variations of *Homo sapiens*,

"…white Europeans, brown Asiatics, black Africans, and red Indians…" and in several later publications, including later editions of *Systema Naturae*, these would be ranked for various features—black Africans were invariably last, but the Sami and indigenous red variants were usually ranked above white Europeans.

Linnaeus' plan for 1733 was to write and lecture; of the dozen books and articles he had planned, one, *Fundamenta Botanica*, was ready for print the following year. In January 1735, he met and wooed his future wife, Sara, and was engaged in three weeks. Apparently, a stipulation of his future father-in-law was to go abroad to study. Linnaeus had been in university for seven years but a doctorate in medicine was not available from Swedish Universities, so it was off to Harderwijk, Holland. A Dutch rhyme of the time translates: "Harderwijk is a trading town/ It sells smoked herrings and doctorates" (p. 110). Again, Linnaeus had the fortune to be introduced to a botanical influencer, in this case Boerhaave, in Leyden, who provided a letter of introduction to Sloane in London and connected him with Clifford, Holland's third-wealthiest trader, who employed Linnaeus in his garden, stocked with European and exotic specimens. When Linnaeus left for Holland in 1735, he brought a stack of manuscripts (Hoffman's 1737 portrait of Linnaeus in a Sami Costume shows at least eight, including: *Systema Naturae; Critica Botanica, Flora Lapponica,* and *Classes Planarum*); by his return to Sweden, in 1738, these were among 14 published works and a growing network of correspondents.

The return to Sweden marked the beginning of Linnaeus' maturation as an academic and administrator. Although he had developed a reputation among botanists abroad, he remained relatively unknown at home. Linnaeus began a medical practice in Stockholm as well as presenting well-received public botany lectures. On 2 June 1739, Linnaeus was elected founding President of the Swedish Royal Academy of Sciences, and 24 days later he married Sara. Academy connections led to projects on behalf of Parliament and ultimately to his move to Uppsala where he was appointed Professor on 5 May 1741. For the next 35 years Linnaeus settled into an efficient and productive routine of teaching, writing, and administrative service. He always had multiple manuscript drafts for books and dissertations in process or in revision as he continued his prolific publishing. This impinged on his homelife as well as his time at the university. Like many young scholars, even today, he "burned the candle at both ends," but this habit persisted even into his later years. In later life his son noted that Linnaeus slept longer in winter than in summer, but he tended to take cat naps throughout the day and botanical work was done mostly during the brightest hours. A visiting student wrote in his notebook that "… when everything was silent in the house, he [Linnaeus] would get out of bed and sit down to work all night toward the morning when he would again to go have a rest and sleep for as long as he believed himself to need." (p. 326).

Linnaeus' longest project was *Systema Naturae*, which went through 12 editions from 1735 to 1766, 1768. The first edition, which included plants, animals, and minerals, was a 12-page manuscript. By the sixth edition, 13 years later, 220 pages were needed to document a total of 26,500 species (about 6000 plants and 5000 animals), and he felt confident in predicting the total number of plants would be less than 10,000. But that year he also received a letter from Peter Kalm, his disciple, about collecting

in North America: "Wherever I looked there were plants I had never before seed. I shudder with dread at this revelation of such a large part of natural history being unknown to us" (p. 337). Beginning with the 10th edition, minerals were no longer included and by the 12th edition, plants and animals filled 2300 pages—10 times as many as 20 years previous when he predicted fewer than 10,000 plants. Linnaeus concluded that new plants were still being created and that the number of species was increasing; he also identified hybridization but thought that would only be important in producing varieties, like the *Homo sapiens* situation mentioned previously. He also knew that his classification system was artificial and that a more natural system would eventually be discovered.

In 1768 he addressed his concerns with the direction of education at the University: "Since 1750, I have sensed how the sciences have more and more declined and still continue waning in our country" (p. 345). But he also realized that his kind of science was now out of favor. The previous year he published *Metamorphosis humane* in which he described the 12 phases that signal old age. To his long-time patron, Carl Gustaf Tessin, he wrote: "At the age of between 20 and 30 years, we believe ourselves to know and understand everything; at least I was never again as convinced of my learning as when I was 24." He was becoming increasingly restricted by his physical limitations, gradually cutting back his commitments and finally retiring in 1776. He died within two years, on 10 January 1778.

Broberg documents Linnaeus' scientific innovations—not only binomial nomenclature, but also his lifelong passion to classify the natural world. His particular passion for botany grew from his father's influence and included both natural science and its practical applications. His father also passed on an appreciation for the value of books so that by the time he left university, he was already a "scribbling Swede"; many of his books were filled with marginal annotations and he was filling notebooks with copious notes from nature, classes, and reading. Later he turned to notecards for filing. He quickly realized that writing was not only a technique for spreading information but a way to gain recognition and support. This helped him "make his own luck" in finding mentors and sponsors and recruiting young botanists. He was a PR man for himself and for botany. His brief travels in Lapland not only introduced him to natural variation due to environmental extremes but led him to develop a deep respect for Sami culture, which influenced his thinking on medicine, human culture and natural history. Finally, I was most impressed with his dedication to teaching and pedagogy, well documented in his own writings and by letters from students and colleagues—all in an effort to recruit more students to botany. Some might voice concern with a lack of political correctness in Broberg's language, but considering that this is a translation and that most of the "offending" terms or ideas are in Linnaeus' own words from 300 years ago, I take that as no offense. In fact, I think that the quotes in the book (there are many both from Linnaeus and his contemporaries) are a strength that draws one into a sense of the times. There are extensive endnotes for each chapter and a thorough listing of sources and literature. True to its title, this is a biography about Linnaeus the man, not just the scientist. Although not for the general reader, it will be of interest to scientists, social scientists, historians, and philosophers of science.

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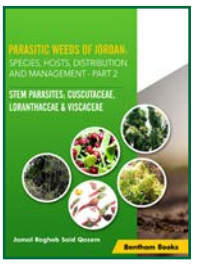
Parasitic Weeds of Jordan: Species, Hosts, Distribution and Management. Part I. Root Parasites: Orobanchaceae, Santalaceae & Cynomoriaceae.



by Jamal Ragheb Qasem. 2022. Bentham Science Publishers, Sharjah, United Arab Emirates. 365+xxiii pages. ISBN 978-1-68108-4. Price not given.

For its size, Jordan has a remarkable diversity of parasitic angiosperms not all of which are "weeds" but rather benign components of the local flora. No one knows these plants better than Jamal Qasem who provides an exhaustive overview of most Jordanian parasitic plants. In person, he is enthusiastic about these parasites; this enthusiasm and depth of knowledge comes to print in this book and provides the most comprehensive national treatment of such plants.

The volumes (I am treating them together) are clearly laid out. There is a thorough introduction to these unusual organisms, enough to introduce the subject to someone new to the subject. This is followed by treatments of each family and genus including the following: germination and development (particularly germane when discussing parasites), contact and attachment; biology, ecology, and physiology; distribution and host range, economic importance (including ethnobotany), and control. The section concludes with many images, and extensive references. Based on the author's intimate knowledge of the weedscape, it is surprising there are no distribution maps for the species.

One could argue over important things like an updated taxonomy. For example, *Cuscuta* has been shown to clearly belong in the Convolvulaceae not the monogeneric Cuscutaceae. The genus *Orobanche* taxonomy is in a state of flux and the author can be excused for using some names not currently recognized.

A truly authoritative work would distinguish among the species in the genus. For example, rather than *Cuscuta* sp., give the species name, e.g., *Cuscuta speciesname.*

The volumes are well edited, the images are not. This could be a magisterial work if there were proper images. They are of inferior quality, often out of focus, and frequently do not clearly display the features mentioned in the legends. And there are too many of them. How many images of branched broomrape on tomato do I need to see to learn that branched broomrape attacks tomato?

A few images are even misidentified, especially in the *Cuscuta* chapter. Page 129 is purported to show *Cuscuta monogyna* on an orange tree but the flowers having two stigmas places this plant in the subgenus Grammica, not the subgenus Monogyna, making it most likely to be *C. campestris.* I am leery of claiming that *Cuscuta* and *Orobanche* species can parasitize grasses, but the images are too inferior in quality to verify the purported parasitic connection.

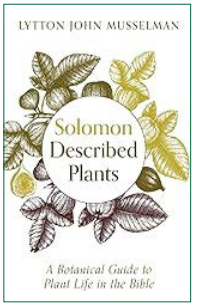
Parasitic plants that are not serious agricultural problems are also included. Two species of mistletoe are discussed as well as the remarkable *Cynomorium coccineum* (Cynomoriaceae) and the strikingly beautiful species of *Cistanche* (Orobanchaceae)—both are genera found in deserts. The genera *Thesium* (Thesiaceae) and *Osyris* (Osyriaceae or Santalaceae) are included. Like the aforementioned they have little economic importance.

A major thrust of the author's work is the documentation of host range for each of the species or species groups he includes. Like other workers, he does not clearly distinguish between host preference and host range. However, unlike some parasitic plant workers, Qasem attempts to show the host-parasite connection, the only way to document authentic parasitism, but again the problem is the blurred picture. Inclusion of pictures showing parasites "under" or "near" a possible host are not helpful. His compilation of hosts is the most complete I know of and is based on his extensive review of the literature as well as his many years studying plants firsthand.

Despite the failure to provide clear images for many if not most of the parasites, this is a book of value to agriculturalists, botanists, ethnobotanists, and extension workers in Jordan as well as those beyond the borders of the Hashemite Kingdom. It is an important contribution to the literature of parasitic angiosperms.

-Lytton John Musselman Old Dominion University and Blackwater Ecological Preserve

Solomon Described Plants: A Botanical Guide to Plant Life in the Bible



Lytton John Musselman
2022. ISBN: 978-1-7252-5576-0
US$47.00 (paperback); 328 pp.
Cascade Books, Eugene Oregon

Solomon described… is a reference to the eight chapters of the Old Testament "Song of Solomon" (Song of Songs) attributed to the Hebrew king/naturalist who mentions 23 different plants or plant products (including caper, henna, saffron, and walnut) in its verses. One of the first things Musselman addresses is which version of the Bible are you referring to? All Bibles are translations, and he examined 13 contemporary English editions and occasionally cites Greek translations and the Qur'an. In total, he describes 80 plants. This is about one third of the species covered by Moldenke and Moldenke (1952) in their classic "Plants of the Bible." Whereas Moldenke includes every name, and alternative possible names, mentioned in each of the translations they examined, Musselman consolidates this information, along with his personal knowledge of current and past habitats and distributions to determine the most likely identification for each of the plants covered.

The general arrangement of the text is similar to that used in the earlier book, an alphabetical arrangement by name, but it is clear that Musselman is targeting a much broader general audience than the botanically focused Moldenke; the order of the present text is by common name. He also includes a few plants "in Bible lore but not in the Bible," most notably apple, that plant so evil in the Garden of Eden that it was given the name *Malus*.

Another clear difference between the texts is Musselman's ethnobotanical orientation. He includes the use of each plant in ancient times as well as contemporary use both by local people and in commercial world culture.

An alternative title might be "Musselman Describes Plants of the Bible" because one of the most delightful aspects of this book are the personal insights the author injects into many of the descriptions, especially of edible plants, spices, and aromatics. For instance, "Looks are deceiving… fresh olive is very bitter and unpalatable…" leads into a brief description of how both fruit and oil were and are processed. Seeing and hearing the roar and popping of burning reeds in a wildfire while doing fieldwork allowed him to relate the terror of soldiers in Jeremiah 51 as a marsh burns out of control. The heat vaporizes water in the stems, which explode as the vapor escapes. He values and relates the insight of locals: "Arab friends warned me that it was very toxic…it reminded me of the taste of ground cherry." Throughout he exhibits a subtle sense of humor. Tamarisk is a genus native to the Dead Sea area that has become invasive in many arid areas: "Tamarisk may be visiting in an area near you." Explanations like these make the text very personal and very relatable.

The book is profusely illustrated with the author's photographs of landscapes, plant habits, closeups of characteristic parts, and economic uses. It has an extensive bibliography of references and subject index and a complete scriptural index. One of the author's stated goals is "to improve the plant fluency for the serious reader of the Scriptures…." It will do likewise for any general reader; I encourage you to recommend it for your local public library as well as school libraries to raise plant awareness!

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