



# PLANT SCIENCE BULLETIN

SPRING 2019 VOLUME 65 NUMBER 1

A PUBLICATION OF THE BOTANICAL SOCIETY OF AMERICA



## Botany as a State of Flow *Enhancing Plant Awareness through Video Games*

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## From the Editor

Greetings,

In this eclectic issue of *Plant Science Bulletin*, we have the story of 2× CTAB isolation, a discussion about the potential of using video games to promote botanical education, and a description of canopy research in Great Smoky Mountain National Park. In the Policy Notes, you will find the latest information about the Botany Bill, and the Student Section highlights opportunities for students.

I am also happy to point you toward our large assortment of book reviews in this issue. As always, we are grateful for the reviewers who take the time to provide a synopsis and critique of the newest botany-oriented books, as well as the publishers who make these titles available. If you are interested in writing a review, the list of available books can be found at <https://cms.botany.org/home/publications/plant-science-bulletin.html>. We also welcome reviews of books that are of interest but not on our list. For more information, please contact me at [mackenzietaylor@creighton.edu](mailto:mackenzietaylor@creighton.edu).

I want to send a special shout-out to our readers and BSA members who are U.S. federal employees and who endured the longest-ever—at least at the time I am writing this—government shutdown in January. Your service to botany, science, and to the United States is appreciated.



*Mackenzie*

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# SOCIETY NEWS

## Public Policy News

### ENGAGE IN BOTANICAL SCIENCE ADVOCACY!

In response to the increased interest in science advocacy, the Public Policy Committee of the BSA is dedicated to providing resources and examples of advocacy strategies to help the scientific community more effectively engage with policy makers. In 2019, the *Plant Science Bulletin's* Public Policy News will highlight upcoming legislation, organizations, and case studies to facilitate greater engagement.

### FEATURED LEGISLATION: REBOOTING THE BOTANY BILL

If you have been involved or interested in advocating for the Botany Bill during the past two years, we need you to spread the word



By **Krissa Skogen** (*Chicago Botanic Garden*),  
**Kal Tuominen** (*Metropolitan State University*),  
and **Andrew Pais** (*North Carolina State University*  
[not pictured]), the BSA PPC Co-Chairs

### **The Botany Bill**

and connect with your elected officials in the 116th Congress!

The Botanical Sciences and Native Plant Materials Research, Restoration, and Promotion Act (aka the “Botany Bill”) was introduced to the 115th Congress in the U.S. House of Representatives (2017; H.R. 1054) and Senate (2018; S.3240). With a new Congress comes the need to reintroduce the Bill and a new opportunity for it to move forward in the legislative process! The “Botany Bill” will be reintroduced in the 116th Congress in both the House and Senate once co-sponsors are identified, ideally in early 2019. In order for the Bill to make it to committee, it will need broad bipartisan support in both the House and the Senate.

Consider contacting your elected officials and asking them to co-sponsor the Bill! We will need all the support we can get—your efforts are needed and valued!

Visit <https://botanybill.weebly.com/> for resources to guide your advocacy efforts, for information on the new version of the Botany Bill, and to sign up for updates on the Bill!

## FEATURED ORGANIZATION: THE PLANT CONSERVATION ALLIANCE

The Plant Conservation Alliance (PCA) is a public-private partnership of organizations that share the common goal of protecting native plants by ensuring that native plant populations and their communities are maintained, enhanced, and restored. The partnership includes 12 U.S. Federal Agency Members (the Federal Committee) and nearly 400 Non-Federal Cooperators (the Non-Federal Cooperators Committee), which is comprised of state agencies and private organizations interested in native plant conservation in the United States. PCA Members and Cooperators work collaboratively to solve the problems of native plant conservation and native habitat restoration, ensuring the sustainability of ecosystems in the United States. The depth and strength of PCA lies in the scientific expertise, networking, and ability to pool resources to protect, conserve, and restore our national plant heritage for generations to come.

In 1995, PCA developed the National Framework for Progress in Plant Conservation ([https://www.blm.gov/sites/blm.gov/files/programs\\_natural-resources\\_native-plant-communities\\_national-seed-strategy\\_pca\\_Framework.pdf](https://www.blm.gov/sites/blm.gov/files/programs_natural-resources_native-plant-communities_national-seed-strategy_pca_Framework.pdf)). This Framework is intended to provide a coordinated approach to plant conservation in the United States. The National Framework consists of six broad strategies and outlines supporting goals and actions to guide efforts for implementing a national plant conservation strategy at national, regional, and local levels.

Cooperators are invited to attend meetings of the PCA's Federal Committee as observers, participate in informal open forums with the PCA Federal Committee, and participate in PCA Working Groups. Cooperators also receive regular communications that facilitate participation in Non-Federal Cooperator Committee efforts to raise awareness about the importance of native plant conservation. In addition, the PCA holds bi-monthly meetings as an open forum for anyone interested in working in plant conservation. The meeting takes place in the Washington, DC metropolitan area and is available remotely as a live webinar. Attendees use a roundtable format to share relevant events and discussion on work related to plant conservation, and each of the PCA working groups and committees provides ongoing updates. Regular attendees include representatives from PCA Federal agencies and from cooperating organizations. However, anyone is welcome to attend the meetings.

### Get Involved with the PCA!

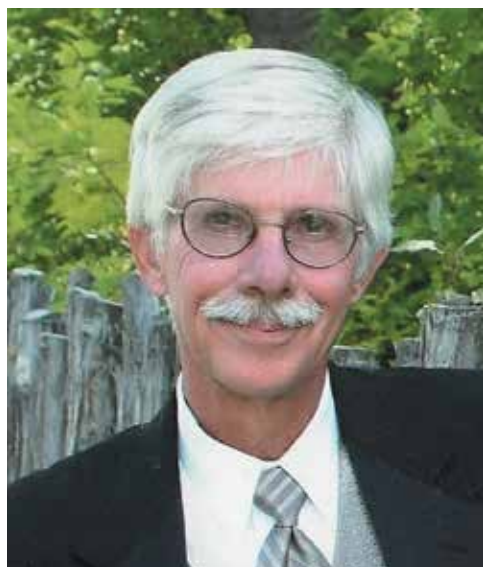
Join the PCA listserv to learn about upcoming meetings, receive announcements, and follow discussions on native plant conservation: <http://lists.plantconservation.org/mailman/listinfo>.

Visit <http://www.plantconservationalliance.org/cooperators> to find out if your organization or agency is part of the PCA.

The schedule for upcoming meetings can be found at <http://www.plantconservationalliance.org/meetings>.

Follow the PCA on Facebook at <https://www.facebook.com/PlantConservationAlliance/>.

# In Memoriam



**HUGH DANIEL WILSON**  
**(1943–2018)**

Hugh Daniel Wilson was born in Alliance, Ohio, to Fern and Elvin Wilson on August 15, 1943 and died November 5, 2018.

He grew up in Alliance and graduated from Alliance High School in 1961. He was a running back on the AHS 1958 Football State Championship team and held a track record at the Ohio State Relays that lasted for nearly 20 years. Hugh was elected to Alliance High School Athletic Hall of Fame in 2000.

Sargent Hugh Wilson was honorably discharged from the United States Air Force 1964-68 with an Air Force medal of Commendation for Meritorious service in Vietnam. After returning from the service, Hugh completed a Bachelor of Arts (Biology) in 1970 and Master of Arts (Botany) in 1972 at Kent State University, Kent, Ohio. Thesis: “The Vascular Plants of Holmes County, Ohio”.

Hugh received his Ph.D. in Botany and Anthropology 1973-1976 from Indiana University, Bloomington, Indiana Dissertation: “A biosystematic study of the cultivated chenopods (Quinoa) and related species”.

After earning his Ph.D., Hugh was a visiting professor on the faculty in the Department of Botany at the University of Wyoming, Laramie, Wyoming. Hugh had full responsibility for a five-week Science Camp offering field Botany.

In 1977, Dr. Wilson joined the faculty at Texas A&M University, College Station, Texas (College of Science), Department of Biology. He taught Taxonomy of Flowering Plants, Field Systematic Botany, and Economic Botany until he retired in 2011 as Professor Emeritus.

Dr. Wilson was known for the study of the floras of Ohio and Texas, with focus on conservation of rare species and habitats, and for his ethnobotanical research and early molecular work on *Lagenaria*, *Cucurbita*, and *Chenopodium*. His enthusiasm for taxonomy, ethnobotany, floristics, conservation, and specimen digitization inspired many of his students to become botanists or pursue related fields, and I am lucky to count myself among them.

Dr. Wilson was the curator of the TAMU Herbarium (now combined with Texas A&M’s Tracy Herbarium, TAES) and was an early, visionary promoter of specimen digitization, herbarium data standards, online collections browsers, and regional consortium building—many years before these ideas became widely embraced and adopted. He was instrumental in the creation of one of the earliest online

herbarium specimen browsers (for TAMU and TAES), and provided leadership for both iterations of the region's herbarium consortia (first, the Digital Flora of Texas Consortium, and later, the Texas-Oklahoma Regional Consortium of Herbaria (TORCH)). Wilson's insistence that botanical data should be digitized so they could be easily shared and updated, and then eventually combined and mined for research—long before Big Data was a thing—made him a pariah, in his own opinion. In my opinion, he is one of the giants upon whose shoulders many of us now stand.

Hugh was given the Edmund H. Fulling Award, Society for Economic Botany, 1981, Fellow American Association for the Advancement of Science 1990. He received support for research from the National Science Foundation, U.S. Department of Agriculture, and National Geographic Society.

Dr. Wilson was a member of the American Association for the Advancement of Science, the Botanical Society of America, the American Society of Plant Taxonomists, and the Society for Economic Botany.

Hugh is survived by his wife, C. Toni (Favazzo) Wilson, College Station, TX; son, Quentin F. Wilson, Portland, Oregon; brother, Gary L. Wilson, Los Angeles, CA., nephews, Derek M. Wilson, Dallas, TX, C.D. Wilson, Sachem, CT; and their children.

In lieu of other forms of commemoration, please take the time to accompany your students in their fieldwork, or invite them to accompany you in yours.

*(Dr. Wilson's obituary was published in the Alliance Review on 10 November 2018. We present it here with additions by Amanda K. Neill.)*



**LANNY FISK**  
**(1944–2018)**

Dr. Lanny Herbert Fisk (1944-2018), beloved brother, father, and friend, left the Earth and life he loved on July 19, 2018. He resided in Grass Valley, California. Lanny was born to Paul J. and Mildred (Courser) Fisk on February 24, 1944. He graduated from Vestaburg High School in 1962. In January of 1967 he married Carolyn McDowell of Detroit, MI. He was drafted into the U.S. Army and served as a Medical Specialist at the U.S. Pentagon from 1967-1969. Following his honorable discharge, he moved to Berrien Springs, MI where he completed an undergraduate degree at Andrews University in 1971. After earning his PhD in Biology, with emphasis on Paleobotany, from Loma Linda University (LLU) in Loma Linda, CA, he taught at Walla Walla College (WWC) in Walla Walla, WA. He then pursued postdoctoral studies in Petroleum Geology at Michigan State University.

Life-long research took Lanny around the world, but his favorite was conducted at Yellowstone National Park (YNP) where he had graduate students working under him doing research on the petrified forests of YNP. His research, often in collaboration with valued colleagues, has been published in several journals, including but not limited to *The Journal of Paleontology*. Geological Society of America (GSA) was the first professional organization he joined and went on to become a member of the Paleontological Society as well as too many others to name. He held teaching positions at WWC, LLU, and most recently, American River College in Sacramento, CA. While at LLU, he and Dr. William J. Fritz incorporated F & F GeoResource Associates, Inc. In 1982 Lanny created, as the Senior Paleontologist and Chief Executive Officer, the consulting firm of PaleoResource Consultants, DBA of F & F. In 1993 he was appointed by the Governor of Oregon to serve on the Board of the Oregon Department of Geology and Mineral Industries, which he did through 1998.

Lanny was very active in AASP-The Palynological Society over the past many years. He was President of the Society in 2014; prior to that he was President-Elect (2013) and then Past-President (2015). While he was President-Elect he hosted and organized the 2014 AASP-TPS Annual Meeting in San Francisco. Lanny fulfilled many wishes of hosting that meeting in San Francisco, with a '60s theme t-shirt, the venue in downtown, and a geologically oriented field trip to the wine country. Over the past decade Lanny was ever present at AASP-TPS annual meetings, giving presentations, participating in board meetings, and participating in other Society activities.

Right up until his passing, Lanny was organizing projects and studies involving fieldwork and travel. He was full of incredible energy and enthusiasm. He had just been talking with Joyce Lucas-Clark about a new project on the California Eocene-Oligocene stratigraphic problems, and had longer-term plans for working on the Chalk Bluffs microflora. Appropriately, Lanny passed away while working at his computer in the office late at night. He had dreams of projects right up until the time of his death. No one knew the extent of his health problems other than his knee replacements. Despite those surgeries and normally bringing up the rear with Joyce on hikes, he thoroughly enjoyed fieldwork. Throughout his professional career, Dr. Fisk was a lecturer, teacher, and mentor to many in the geology and paleontology community.

In 1996 Lanny married Tami Wanner. Their children are Daniel (21), Michael (19), and Dessa (16), who all live in the Sacramento area. Lanny's family also includes his sisters, Paula Fardulis of Carlsbad, CA, and Susan Brantley of Vestaburg, MI. Lanny had valued relationships with many cousins, nieces and nephews, great nieces and great nephews, who tolerated the teasing and practical jokes that came along with his wit. Those of us who were close to him have lost a very good friend.

*-Joyce Lucas-Clark and Thomas Demchuk  
Excerpts taken from Legacy.com*

*Reprinted from the AASP – The Palynological Society Newsletter 51 (4): 15-16.*





## NEIL ARTHUR HARRIMAN (1938–2018)

Neil Arthur Harriman died at home on December 7, 2018 after a rather lengthy decline in his health.

Neil was born on August 1, 1938 in St. Louis, Missouri, the only son of Ruth and John Harriman. He grew up in St. Louis along with his older sister, Ruth. Neil received his Bachelor of Arts from Colorado College, Colorado Springs, Colorado, in 1960, followed by a Doctor of Philosophy from Vanderbilt University in Nashville, Tennessee, in Biology in January 1965.

While at Vanderbilt, Neil met Bettie Ralph and they were married on July 13, 1963. Together, they moved to Oshkosh, Wisconsin, in September of 1964 when Neil joined the Biology Department faculty at University of Wisconsin Oshkosh (UWO), primarily to teach botany classes and do plant taxonomy research. Neil remained at UWO until his retirement in May 1998.

Neil was a dedicated teacher and found great satisfaction not only in teaching about botanical information, but helping the students learn to be life-long learners. It gave him much pleasure that three of his students went on to get their own PhDs in Botany: Robert Jansen, Bruce Parfitt (deceased), and Melanie DeVore. His research work of collecting, identifying, and conserving plants was also a pleasure to him. When Neil arrived on campus in 1964, the herbarium facility in Halsey Science was barely more than a room with cabinets waiting to be filled with dried, identified, and properly labeled plants, arranged in a systematic fashion. Today it houses almost 125,000 specimens from around the world, including over 70 type specimens; three of these document species named in Neil's honor: *Flyriella harrimanii*, *Lundellianthus harrimanii*, and *Phyllanthus harrimanii*. After Neil's retirement, the university named the herbarium in his honor. The Neil A. Harriman Herbarium contains not only plant specimens, but Neil's extensive personal botanical library as well.

Neil belonged to numerous botanical societies during his career, including American Society of Plant Taxonomists, for which he served a three-year term as Secretary and Program Chairman, and the International Association for Plant Taxonomy. He served as Editor of *The Michigan Botanist* for many years, and as a reviewer and author in the Flora of North America project of the Missouri Botanical Garden. Over the years he published numerous scientific articles in the journals of these societies.

During his 34 years as a member of the UWO faculty, Neil received a number of awards and recognitions. In 1973–1974, he was given the Citation as an Outstanding Teacher. In May 1986, Neil was named a John McNaughton Rosebush University Professor for Excellence

in Teaching and Professional Achievement. In 1993 he received the UWO Endowment for Excellence - The TRISS Endowed Professorship.

When Neil retired in 1998, he was named Professor Emeritus of Biology and Microbiology at UWO by the Board of Regents and continued to work in the herbarium as long as his health allowed.

Neil's joy for editing the written word extended beyond botany, as did his willingness to "help out" when needed. During his retirement, Neil joined his wife Bettie as co-editors for the quarterly journal of the Wisconsin Society for Ornithology from 2003 to 2014. He also contributed his editing skills to the production of the *Atlas of the Breeding Birds of Wisconsin*, a 600-page book published by the Wisconsin Society for Ornithology in 2006.

The essence of Dr. Neil A. Harriman is perfectly stated by one of his graduate students, Tom Eddy: "Forty years ago, as a young graduate candidate at the University of Wisconsin Oshkosh, I was encouraged by Dr. Neil A. Harriman to conduct a systemic study of the vascular flora of Green Lake County. My thesis research and association with Neil resulted in a profound change in my life trajectory, both personally and professionally.

"Besides our independent plant collecting, Neil and I participated in numerous botanical outings organized by the Botanical Club of Wisconsin. Neil's taxonomic knowledge was encyclopedic. He exercised a superlative command of language and proper use of grammar. Whether in lecture or private conversation, he could turn what first appeared to be a collection of unrelated facts into a relevant lesson, frequently accompanied by humorous euphemisms.

"Neil was an unpretentious and modest person, preferring not to draw attention to himself. In 2009, the herbarium which Neil founded in 1964, was dedicated in his honor: the Neil A. Harriman Herbarium. While such an honor might offer one an opportunity to grandstand, Neil chose not to speak at this ceremonious tribute.

"The natural world was held in reverence by Neil. Whether botanizing a natural area, roadside right-of-way, or parking lot, his eye was trained on the ground. Besides collecting new plant records, Neil regularly collected and properly disposed of someone else's litter.

"Neil gifted generously to his local animal shelter. He held a tender spot for cats and dogs waiting to be adopted. On numerous occasions I witnessed a similar mindfulness by Neil toward other peoples' lives whose unfortunate circumstances were less than ideal. He was generous, big-hearted and aspired for the common good. For all this, I owe Neil a debt of gratitude for his mentorship and unflagging friendship."

Neil is survived by his wife Bettie and many friends who offered comfort and assistance with his care. His final week was under the excellent care of Aurora At Home hospice care, which gave much physical support and comfort to Neil in a most experienced and professional manner while at the same time providing an easy emotional and caring support for Bettie.

-*Thomas G. Lammers, Ph.D., Professor Emeritus, Department of Biology and Microbiology, University of Wisconsin Oshkosh*

# 5 Things About Your Executive Director



*Heather Cacanindin was named the BSA Executive Director in March 2018, after a competitive search to replace Bill Dahl, who retired in October 2017. Prior to taking over the reins of the Society, Heather served as the Director of Membership and Marketing for the BSA, the Society for the Study of Evolution, and the Society for Economic Botany for over 10 years.*

**Why did you want to be the Executive Director of the BSA, and what makes you excited to come to work?**

I have spent my entire career in association and nonprofit work. I love working for organizations that are truly mission-driven and making an impact on the communities that they serve. After ten years at the BSA, I felt that I had a deep understanding of the organization, its culture, and our staff and our members' needs. BSA does such a great job in serving its members in every career stage, and our members are doing fantastic and exciting

research and outreach. It is invigorating to know that we are all here to nurture scientific discovery, provide professional development opportunities, and pave the way for the next generation of botanical scientists. I find that there are so many dedicated members and leaders in this organization, and that makes coming to work each day really worthwhile and fulfilling. I know the rest of our staff feels the same way. And also, our BSA staff is just fantastic to work with!

**What is the most surprising or challenging thing you have encountered in your first year as Executive Director?**

It was surprising to me just how long it took to get up to speed in an organization that had been my home for several years. There were still so many aspects of our business that I had only tangentially been exposed to. I realized quickly that there was still so much for me to learn at the BSA, and that was challenging, a little scary, and exciting all at the same time.

**In what way is serving in this role different than you imagined?**

It's hard for any organization to transition from a long-time Executive Director to a new leader. I don't think I realized just how much our Board, members, and staff were looking to me to set the tone and direction for the next phase of BSA's evolution. I also realized quickly that it was hard for me to let go of some of my previous work that was familiar and comfortable in favor of some of the new initiatives and work on my desk as Executive Director. Luckily, with the help of our staff, leadership, and a terrific new Membership Manager to fill my previous role, I have been able to make the pivot.

**Who is a person who has influenced and/or inspired you in your work?**

I had a fantastic mentor at the United Soybean Board, when I worked there several years ago. She taught me to always put forth my best effort, do my research, and really listen to my leaders and constituents. I also learned from her that sometimes you have to speak your mind and stand up to your leadership if they are getting off track or engaging in mission-creep. Running an association is a partnership between the leadership and the staff, but the direction of the organization really rests with the members and the mission of the organization. She also taught me that it is important to continue to sharpen my skills and support my staff in their own professional development. Thanks, Janice!

**And finally... what do you like to do in your spare time?**

I love to read, travel, and watch my two sons play hockey.



# Applications in Plant Sciences

*Applications in Plant Sciences*  
Two Special Issues This Spring

The March issue of *Applications in Plant Sciences* is focused on “Emerging frontiers in phenological research.” This special issue, organized by guest editors Gil Nelson, Elizabeth Ellwood, and Katelin Pearson, includes articles presenting innovative phenology projects—all of which make use of, or can be applied to, herbarium specimens—that offer new insights into research methods, software, and foundational standards and practices.

**The full issue is available at**

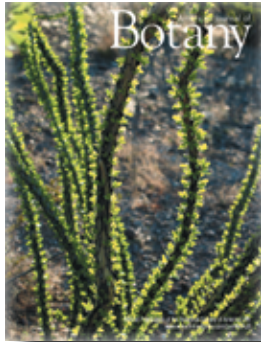
**<https://bsapubs.onlinelibrary.wiley.com/toc/21680450/2019/7/3>**

*APPS* will feature another special issue in April, with “Methods in Belowground Botany.” Guest editors Gregory Pec and James Cahill have curated a diverse group of papers that explore current methods and challenges in investigating plant root systems, ranging from the sub-cellular to the ecosystem level, with a wide variety of applications that advance our understanding of belowground botany.

**Upcoming articles for this issue are available at**

**<https://bsapubs.onlinelibrary.wiley.com/toc/21680450/0/0>**

# The Benefits of Publishing in BSA's Research Journals



The publishing landscape is changing constantly, and authors have many options for publishing their research. The BSA's two peer-reviewed journals—the *American Journal of Botany* and *Applications in Plant Sciences*—want to be the home for your work!

How do your Society journals stand out in today's crowded publishing field?

- *AJB* and *APPS* have a **broad international reach**, which is increasing even further through our partnership with Wiley.
- As a BSA member, **you can publish for free in *AJB*, and you receive discounts for publishing in *APPS*** (a totally Open Access methods journal). See member benefits for full details.
- **Our editorial boards** have broad botanical expertise and handle papers with great care and efficiency (the average time to first decision is ca. 30 days).
- Your **BSA publications team**—Amy McPherson, Beth Parada, and Richard Hund—works with authors, reviewers, and editors to maintain high standards and an efficient and constructive process from manuscript submission through publication.
- **We support authors post-publication** through social media promotions, press releases, and other outreach.

There is an added bonus for publishing in *AJB* and *APPS*: As nonprofit Society journals, our **proceeds go back to the BSA's members and the botanical community** to support grants and awards that further careers and opportunities.

Submit articles now for *AJB* at <https://bsapubs.onlinelibrary.wiley.com/hub/journal/15372197/homepage/forauthors> and for *APPS* at <https://bsapubs.onlinelibrary.wiley.com/hub/journal/21680450/homepage/forauthors>.

We look forward to seeing your best research appear in your Society journals!



# ANNOUNCEMENTS

## NEW ONLINE CERTIFICATE IN TROPICAL FOREST LANDSCAPES

The Environmental Leadership & Training Initiative (ELTI) is proud to announce the launch of a new online certificate program, in collaboration with the Yale School of Forestry & Environmental Studies, titled: Tropical Forest Landscapes: Conservation, Restoration and Sustainable Use.

This yearlong program consists of four eight-week online courses, a capstone project, and an optional field course in Latin America or Asia. This program is designed for professionals working to address the complex social, ecological, and funding aspects of managing tropical forest landscapes.

Learn from a diverse team of Yale faculty members, ELTI team members, and a network of international partners:

- **Fundamentals:** Ecological and social concepts
- **People:** Community and institutional engagement
- **Strategies:** Implementing and monitoring techniques
- **Funding:** Financial concepts and tools
- **Capstone:** Designing a conservation or restoration project

The program will run from June 2019 through May 2020. Applications open January 7, 2019.

Interested in learning more? Visit our website at [tropicalrestorationcertificate.yale.edu](http://tropicalrestorationcertificate.yale.edu) for more information and sign up for our mailing list to receive important program updates.

## MSC DEGREE/POSTGRADUATE DIPLOMA IN THE BIODIVERSITY AND TAXONOMY OF PLANTS Royal Botanic Garden Edinburgh, University of Edinburgh

### Programme Philosophy

The MSc in Biodiversity and Taxonomy of Plants is a full one-year master course established by the University of Edinburgh and the Royal Botanic Garden Edinburgh (RBGE) in 1992 to address the growing worldwide demand for trained plant taxonomists and whole-plant scientists. Since then the course has developed into the ideal platform for the study and understanding of plants and their conservation. The RBGE course is unique in its broad approach with a strong emphasis on plants and their identification. Students will also have the once-in-a-lifetime opportunity to be part of a two-week field trip to Colombia to undertake tropical plant identification.

The MSc is ideal for those wishing to develop a career in many areas of plant science:

- Survey and conservation work in threatened ecosystems
- Assessment of plant resources and genetic diversity
- Taxonomic research
- Management of institutes and curation of collections
- A stepping stone to PhD research and academic careers

The course and students benefit widely from the close partnership between RBGE and the University of Edinburgh (UoE). RBGE has one of the world's best Living Collections (>15,000 plant species across our four specialist Gardens—5% of world species), an Herbarium of three million specimens, and one of the UK's most comprehensive botanical libraries. The School of Biological Sciences at UoE is a center of excellence for research in Plant Sciences and Evolutionary Biology. Recognized experts from RBGE, UoE, and from different institutions in the UK deliver lectures across the whole spectrum of plant diversity. Most course work is based at RBGE, close to major collections of plants, but students have full access to the extensive learning facilities of the university.

Edinburgh is a unique place to study plant taxonomy and diversity. RBGE is one of the top four botanic gardens in the world and a global leader in plant science and conservation. The organization dates back to 1670 and will celebrate its 350th anniversary in 2020. Edinburgh, Scotland's capital city, is also a unique and vibrant city in which to live and study, welcoming students from around the world.

## **Aims and Scope**

The MSc provides biologists, conservationists, horticulturists, and ecologists with a wide knowledge of plant biodiversity, as well as a thorough understanding of traditional and modern approaches to pure and applied taxonomy. Apart from learning about the latest research techniques for classification, students should acquire a broad knowledge of plant structure, ecology, statistical methodology, and plant identification.

## **Program Structure**

This is an intensive 12-month program and involves lectures, practicals, workshops and essay writing, with examinations at the end of the first and second semesters. The course starts in September of each year and the application deadline is normally 31 March.

Topics covered include:

- Evolution and biodiversity of the major plant groups, fungi and lichens
- Plant geography
- Conservation and sustainability
- Production and use of floras and monographs
- Biodiversity databases
- Phylogenetic analysis
- Population and conservation genetics
- Tropical field course, plant collecting and ecology
- Curation of living collections, herbaria and libraries
- Plant morphology, anatomy and development
- Molecular systematics

Fieldwork and visits to other institutes are an integral part of the course. There is a two-week field course to Colombia in which students are taught a unique approach to tropical plant identification using mainly vegetative characters, field collections, and ecological survey techniques. The summer is devoted to three months of a major scientific research project of the student's choice or a topic proposed by a supervisor. These research projects link in directly with active research programs at RBGE

### **Entry Requirements**

Applicants should ideally hold a university degree, or its equivalent, in a biological, horticultural, or environmental science, although any well-motivated applications from other fields will be considered, as we are looking above all for candidates having a genuine interest in plants. Relevant work experience is desirable but not required. Evidence of proficiency in English must be provided if this is not an applicant's first language.

### **Funding**

There are a few funding options from the University of Edinburgh. Other international

funding bodies have supported overseas students in the past.

### **Further Information**

For further details on the program, including a course handbook, please visit the RBGE website: <https://www.rbge.org.uk/learn/professional-courses/m-sc-postgraduate-diploma-in-the-biodiversity-and-taxonomy-of-plants/> or <https://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/view&edition=2018&id=1>.

If you have any questions or queries, you are most welcome to contact the Course Director at RBGE, or the Postgraduate Secretary of the University of Edinburgh:

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# SPECIAL FEATURES

## CATB Isolation: The True Story

A critical step in a molecular systematic study is the isolation of DNA suitable for subsequent use. In the early 1980s, plant molecular biology was in its infancy, confined initially to model species—primarily maize and other cultivated plants (the *Arabidopsis* era was still some years away). DNA typically was isolated from large amounts of tissue, often 20 g or more, most commonly by laborious, expensive, several-day protocols that required CsCl density gradient ultracentrifugation and yielded low amounts of DNA, often broken down. For many questions, particularly systematics and population biology, quick and inexpensive methods suitable for large numbers of samples were needed.

In the laboratory of Roger Beachy at Washington University in St. Louis, where Jeff was a postdoc with Roger and Walter Lewis, and Jane a technician from 1981 to 1984, as well as after our move to Cornell in 1984, we

experimented with a number of published and unpublished “miniprep” methods, particularly Appels and Dvorak (1982), with variable success on different species and tissues, while continuing to use the CsCl method taught to us by Liz Zimmer (Rivin et al., 1982) for large-scale leaf isolations. In 1985, we tried a protocol we found in a paper on ribosomal RNA gene (rDNA) variation in barley (Saghai-Maroo et al., 1984)—rDNA restriction fragment length polymorphisms were then a cutting-edge systematics tool—a useful-looking DNA isolation protocol using the detergent cetyltrimethylammonium bromide (CTAB) that the authors described as a modification of a method by Murray and Thompson (1980).

Our notebooks show that we did our first CTAB isolation using the Saghai-Maroo et al. (1984) protocol on May 8, 1985, using 0.13 g of *Glycine tomentella* and 0.44 g of *Pseudovigna*



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*argentea*. The result: “Insoluble pellets!” A day later we were back to using the Appels and Dvorak (1982) method, and continued to use that while we experimented with a method for isolating pure chloroplast DNA (Bookjans et al., 1984). But we were also still in the market for a total DNA miniprep, and hadn’t given up on CTAB, trying the Saghai-Marroof et al. (1984) method again in August, and once more in December, without great success. Then, in the lab notebook on January 17, 1986, is a note to “try using 2× Saghai-Marroof CTAB bfr. (they used lyophilized tissue!)” Doubling the buffer concentration compensated for the water content of the fresh leaf tissue we were using, which had diluted the detergent—the modification worked, and from that point on we switched to 2× CTAB in our lab for all of our miniprep isolations.

In the summer of 1986, at the AIBS conference at the University of Massachusetts, Amherst, we participated in a discussion at the BSA Phytochemical Section meeting about the new DNA approaches that were bringing the estimation of relationships closer to the level of the gene than could the use of flavonoids and other secondary compounds. It was decided that the Phytochemical Section should offer itself as a home for this form of “molecular systematics,” and, to further that goal, we were invited to publish the 2× CTAB protocol in the *Phytochemical Bulletin*. We accepted the invitation, and Doyle and Doyle (1987) appeared in the January-March issue of that quarterly periodical, edited in 1987 by David Giannasi, and comprising approximately 30 printed pages stapled together and included with the *American Journal of Botany* mailing to members of the Section. Over 10,000 citations later, one might say of this simple modification of someone else’s procedure that “the rest is history”... but the story only got more interesting after that publication.

With an effective DNA isolation protocol in hand, we worked with Elizabeth Dickson, then a graduate student in our lab, on a series of experiments using dried, frozen, and preserved leaves, to determine the conditions under which DNA suitable for restriction digests could be obtained with the 2× CTAB method. Those results were reported in *Taxon* in 1987 (Doyle and Dickson, 1987), in a paper that, although it is the only version of the protocol published in a conventional journal, has been cited only 286 times. Two years later we were asked by a representative of Bethesda Research Laboratories, Inc., a major provider of restriction endonucleases at the time, to publish the 2× CTAB protocol in their trade publication, *Focus*; that version appeared as Doyle and Doyle (1990) and has now been cited over 11,000 times. In 1990 we were asked to present tutorials on molecular methods at a NATO workshop on “molecular taxonomy” and published a set of “DNA Protocols for Plants” (Doyle and Doyle, 1991) in the workshop proceedings volume. That paper has been cited over 750 times.

In 1992, during a seminar trip to Texas A&M University, we met a faculty member, Brian Taylor, who informed us that he had published a protocol identical to the 2× CTAB method in 1982, also in *Focus* (Taylor and Powell, 1982). We had been completely unaware of this—as, apparently, had been the editor of *Focus*! We also learned that in 1985, Rogers and Bendich (1985) had published a method based on that procedure and on the even earlier protocol of Murray and Thompson (1980), and had used it, as we later did, to test the ability of DNA to survive under conditions of drying and preservation. Their paper has been cited over 1200 times.

We have never tried to take full credit for this protocol; Saghai-Marroof et al. (1984) is

mentioned in the abstract of the *Phytochemical Bulletin* paper, and the text states that the method is “a very simple modification of a procedure originally described for barley by Saghai-Marooif et al. (1984), differing principally in that their procedure called for using lyophilized tissue, while we use fresh leaf material, and have compensated for the increased water content by increasing the concentration of the extraction buffer.” For years, when people have requested copies of the protocol from us—typically librarians who cannot find either *Phytochemical Bulletin* or *Focus*, both of which are nearly impossible to locate because of, apparently, not being conventional journals—we have sent a PDF file that provides, along with the protocol itself, a short version of this history, including providing as much of the reference to the Taylor paper as we have (“Taylor and Powell, 1982, *Focus* 4: 4-6”) and the history he related to us. We could have saved ourselves a lot of time and effort—at the expense, it is true, of over 20,000 citations!—had we known of the existence of these other CTAB protocols in the 1980s. But it should be remembered that finding relevant papers was a major task in the days before the internet made searching the vast literature simple. We found Appels and Dvorak (1982) and Saghai-Marooif et al. (1984) not because of their DNA protocols, but because they discussed rDNA evolution.

By a series of accidents of fate, the two Doyle and Doyle protocols (1987, 1990) have been used worldwide now by generations of scientists, and it is not uncommon for us to be asked to pose for photographs with people at international conferences because of this, which is a bit embarrassing. An article in *Nature* (Van Noorden et al., 2014) discussed the 100 most-cited papers in the history of science—which in 2014 meant papers with

at least 12,000 citations in the Thompson Reuters collection of over 58 million papers. None of our papers reporting the 2× CTAB method made the top 100 list, nor would they even now—but if summed they would have qualified as the 48th most cited paper of all time. Considering the topics of these most highly cited publications, Van Noorden et al. (2014) noted that papers reporting useful protocols dominated the list, and summed up with the following quote: “If citations are what you want, devising a method that makes it possible for people to do the experiments they want at all, or more easily, will get you a lot further than, say, discovering the secret of the Universe.” The 2× CTAB procedure is a prime example!

## LITERATURE CITED

- Appels, R., and J. Dvorak. 1982. The wheat ribosomal DNA spacer region: Its structure and variation in populations and among species. *Theoretical and Applied Genetics* 63: 337-348.
- Bookjans, G., B. M. Stummann, and K. W. Henningsen. 1984. Preparation of chloroplast DNA from pea plastids isolated in a medium of high ionic strength. *Analytical Biochemistry* 141: 244-247.
- Doyle, J. J., and E. E. Dickson. 1987. Preservation of plant samples for DNA restriction endonuclease analysis. *Taxon* 36: 715-722.
- Doyle, J. J. and J. L. Doyle. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin* 19: 11-15.
- Doyle, J. J. and J. L. Doyle. 1990. Isolation of plant DNA from fresh tissue. *Focus* 12: 13-15.
- Doyle, J. J. and J. L. Doyle. 1991. DNA and higher plant systematics: some examples from the legumes. In: G. Hewitt, A. W. B. Johnson, and J. P. W. Young (eds.), *Molecular Techniques in Taxonomy*. NATO ASI Series H, Cell Biology Vol. 57, pp. 101-115.

Murray, M. G., and W. F. Thompson. 1980. Rapid isolation of high molecular weight plant DNA. *Nucleic Acids Research* 8: 4321-4325.

Rivin, C., E. Zimmer, and V. Walbot. 1982. Isolation of DNA and DNA recombinants from maize. In *Maize for Biological Research*, ed. W.F. Sheridan. Plant Molecular Biology Association and University of North Dakota Press, pp. 161-164.

Rogers, S. O., and A. J. Bendich. 1985. Extraction of DNA from milligram amounts of fresh, herbarium, and mummified plant tissues. *Plant Molecular Biology* 5: 69-76.

Saghai-Marooof, M. A., K. M. Soliman, R. A. Jorgensen, and R. W. Allard. 1984. Ribosomal DNA spacer-length polymorphisms in barley: mendelian inheritance, chromosomal location, and population dynamics. *Proceedings of the National Academy of Sciences of the United States of America* 81: 8014-8018.

Van Noorden, R., B. Maher, and R. Nuzzo. 2014. The top 100 papers. *Nature* 514: 550-553.

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# Botany as a State of Flow

## *Enhancing Plant Awareness through Video Games*

No doubt my botanical leanings can be attributed to an innate sense of connection with plants. From an early age, I began to wonder what it must be like to be a plant; I even started my own garden at the age of 10. I admit that I was deeply influenced in my choice of interests. I was fortunate enough to have a dad who introduced me to gardening and horticulture. His immense gardens were a thing to behold—flowers, vegetables, fruit trees, all very productive and well-tended (in part due to my conscripted labor). Then later, as a teen, I had a high school science teacher who inspired me to dig deep, to be curious, and to appreciate and understand the science of plants.

Not many kids in the neighborhood appreciated my garden. They would have been what we now call *plant blind* (Wandersee and Schussler, 2001). Sadly, nothing has really changed since then, and the term is now even used by the popular press (Blackhall-Miles, 2015). Dugan (2016) points out that our disconnect with plants and nature is worsening, and that in Shakespeare's time, audiences were much more plant-savvy than the urbanized populations of today. One sign of the times is that the horticulture industry



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### KEY WORDS

digital educational tools, educational games, gamification, plant appreciation, plant blindness, video games

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cannot attract enough young people to fill the available jobs (Higgins, 2018).

But since you are reading this article, it's probably safe to assume that you have more than a passing interest in plants. You are probably not plant blind. Perhaps, if you are like me, you even find that when you are working with plants, you enter a state of bliss—a state of flow, as coined by psychologist Mihály Csíkszentmihályi. Flow is a state of total immersion or concentration, a state where nothing else matters and happiness is all there is. Csíkszentmihályi (1975) found that this special state of mind often occurs when playing games. The term has entered the lexicon of video game culture to describe that joyous state of complete and utter engagement (Cowley et al., 2008).

Where does this state of bliss come from in games? In her fascinating book *Reality is Broken*, video game designer Jane McGonigal

(2011a) investigates the reasons why so many people would rather be on an adventure in a virtual world than live in the real one. She says it's because games offer four psychological benefits that are often lacking in the real world: satisfying work, the experience of being successful, social connection, and meaning. Well-designed games are, in effect, happiness engines.

Video games offer an opportunity to (re)ignite an interest in plants (Dugan, 2016). In fact, a number of 21st-century electronic tools are now being used to highlight the importance of plants. The highly successful YouTube channel Plants are Cool Too (<https://www.youtube.com/user/PlantsAreCoolToo>), produced by Chris Martine at Bucknell University, and the Bloom video series (<http://www.seedyourfuture.org/BLOOM>) produced by the non-profit group Seed Your Future, are making headway in engaging the public in botany. Botany podcasts, websites, blogs, and social media pages abound. However, one glaring area of deficiency is video games.

Let's have a look at some recent statistics from the Entertainment Software Association (ESA, 2018):

- More than 150 million Americans play video games, with 45% being female.
- Sixty percent of Americans play video games daily.
- Gamers are getting older—the average American female gamer is 36 and the average male is 32, with about 12% being over 50 in both cases.

And how much time is spent gaming? Recent surveys from six countries, including the United States, show about six hours per week on average (Limelight Networks, 2018). That may not sound like much, but consider the long term: 15 years of playing, which is not

at all unusual, would be equivalent to all your time spent in high school (estimated at 4682 hours). One should also consider scale. It's reputed (McGonigal, 2011b) that the players of World of Warcraft have accumulated more than 6 million years of gameplay, more time than was needed for Australopithecus to evolve into present-day humans. It's an astounding statistic, and one which makes me wonder what education would look like if that same commitment could be spent on games meant for learning. Given that there are 2.6 billion gamers worldwide (ESA, 2018), playing within 15 genres and 40 sub-genres (Wikipedia, 2018), surely there is room for the creative development of games about botany.

To find out, I conducted an informal search for games related to plants and botany on two popular desktop platforms for games, Steam and itch.io, and one mobile platform, the Apple App Store. Some information was also gathered for the Xbox 360 as a console platform comparison. Steam is the world's foremost commercial distribution site for desktop games, while itch.io is more widely used for indie (independent) titles. Approximately 2% and 1% of games available on Steam and itch.io, respectively, were tagged as educational (Table 1). No information was available for the App Store, and the Xbox 360 lists only five games of 1291 (0.4%) as being educational.

A fair number of games were tagged with plant-related words such as forest, gardening, nature, or farming, or had those words in the title or description for all three platforms (Table 1). This can be misleading. For example, the term forest in the title does not necessarily mean the game is about the plants in a forest, but rather that the forest is a backdrop for the game. For example, in Gardenscapes (Playrix Games) and Blossom Garden (Legend Dreams), the plants are largely incidental. In

**Table 1.** *Number of games found on different platforms.*

Search Term or Tag	Desktop		Mobile
	<i>Steam</i> <sup>1</sup>	<i>itch.io</i> <sup>2</sup>	<i>Apple App Store</i> <sup>3</sup>
<b>Total Games</b>	26,719	123,401	361,877 <sup>4</sup>
<b>Educational</b>	194	1,392	- <sup>5</sup>
<b>Forest</b>	1119	145	134
<b>Gardening</b>	241	80	91
<b>Nature</b>	1125	314	152
<b>Farming</b>	511	256	133
<b>Plants</b>	568	0	58
<b>Science</b>	730	0	200
<b>Botany</b>	7	0	14
<b>Educational &amp; Forest</b>	5	0	87
<b>Educational &amp; Gardening</b>	2	1	22
<b>Educational &amp; Nature</b>	11	13	104
<b>Educational &amp; Farming</b>	3	4	196
<b>Educational &amp; Plants</b>	10	0	135
<b>Educational &amp; Science</b>	41	0	200
<b>Educational &amp; Botany</b>	2	0	10

1. Used a combination of search terms and tags, accessed August 25, 2018; URL: <https://store.steampowered.com/>
2. Used tags exclusively, accessed August 24, 2018; URL: <https://itch.io/>
3. Used search terms exclusively with the fnd.io search facility, accessed August 25, 2018
4. Estimate provided by statista.com for first quarter, 2018.
5. Data not available.

the tower defense game *Plants vs. Zombies*, by PopCap Games, plants are obviously central to the gameplay, but could just as well be insects or robots.

Those games with plants forming an integral part of the gameplay offer an opportunity to fulfill two important roles. The first is to raise awareness of plants without necessarily teaching botany. Success here depends on the objectives of the game developer. *Botanicula*, by Amanita Design, is a beautifully stylized point-and-click adventure game. The main characters are botanical creatures on a mission to rid their tree of evil parasites by solving puzzles and collecting useful items. The simulation game *Viridi*, by Ice Water Games, has the player tending to succulents, watching them slowly grow and flourish. The atmosphere is meditative, and the primary purpose is to relax the player. Similarly, the main purpose of the adventure/art game *Flower*, by that game company [sic], is to evoke strong emotions. The open world adventure game *Skyrim* (in the *Elder Scrolls* series by Bethesda Game Studios) allows the player to visit different biomes and to collect plants with certain alchemical properties, thereby elevating the role of plants in the game.



**Figure 1.** In-game screenshot of a player-created garden in *Solarium*.

It also allows the player to mod (modify) plants found in the game (for examples, see Nexusmods at <https://www.nexusmods.com/skyrim/mods/58091/>), which is an effective way to get people thinking about plants. This build-your-own plant idea is also used in other games. In the adventure game *Solarium* (Figure 1), by Sunfleck Software, the player is a novice botanist in a futuristic world who is given the opportunity to create her own imaginative plants for doing well in training. (Full disclosure: Sunfleck Software is my game studio.) Finally, in a simulation aimed entirely at creative expression, *Mendel*, by Owen Bell, lets the player create an endless array of plant forms and family histories, with the underlying algorithms based on sound classical genetics.

The second role of plant-focused games is to actually teach botany. Do these games exist? When combining the *education* tag with plant-related terms (Table 1), the number of games drops for all platforms, although not so much in the App Store (for unknown reasons). So the answer is yes, but the percentages of educational plant-related games on all three platforms are very low.

The educational game category is not mutually exclusive of other genres. There is nothing to prevent a plant science game from being educational but in the format of an adventure or strategy game. Yet many are simple quizzes, particularly on mobile. Quizzes can be fun, but it's a shame that the rich ecosystem of genres has not been more fully utilized for botanical games. But there are exceptions. One of the earliest examples is *SimPark*, a simulation game released by Maxis in 1996. Players manage a park and, in the process, learn ecological principles and the natural history of North American plants. There is even a dichotomous key for plant (and animal) identification. Now independent



studios are beginning to realize the potential. The casual game *Crazy Plant Shop* (Figure 2), by Filament Games, is a clear exception to the quiz genre, where players learn about genes and inheritance by breeding zany plants. It has received 75% positive reviews on Steam, showing that a well-crafted educational game can be well received. Another highly interactive casual game by Filament Games, *Reach for the Sun*, teaches plant structures and processes. *Tyto Online* is a massively multiplayer online role-playing game (MMORPG) by Immersed Games. Although not exclusively about plants, it has modules about ecology, and growth and genetics, where the player learns science concepts through quests and sandboxes (that is, the player can change his virtual world at will). *Niche*, by Stray Fawn Studio, is an interesting genetics survival game—unfortunately without a plant component. But the point is that there are exciting new initiatives that take full advantage of current video game technology and trends to teach biology.

Video games are a remarkable convergence of artistic and technical creativity—music, art, 3D graphics, story, environmental design, characters, and animation to name a few. And yes, even writing code is a creative process. Just to make my point, *Baba Yetu*, a song by Christopher Tin composed in 2005 as the theme song for the video game *Civilization IV*, by Firaxis Games, won a Grammy Award for Best Instrumental Arrangement Accompanying Vocalists. It was the first piece of music composed for a video game to win a Grammy. Another example: in 2017, an 11-minute trailer for the video game *Everything*, by David O'Reilly, was the first video game trailer to qualify for an Academy Award nomination for Best Animated Short Film.



**Figure 2.** *In-game screenshot from Crazy Plant Shop.*

But building a video game is a complex and lengthy journey. It is especially difficult to make a fun game about science. This is why scientists and game developers, each with their own expertise, should work together. This is already happening with crowd-sourced science where players help resolve scientific problems through gameplay. Foldit, an online game developed by the University of Washington Center for Game Science in collaboration with the Department of Biochemistry, has players (with no biochemistry background) fold proteins to achieve new structural configurations, some of which could be used in the real world. A resulting paper (Cooper et al., 2010) acknowledged over 57,000 Foldit players. That must be a first for any science journal. One interesting approach is to mod an already existing game. This is what a team of biochemists and game designers at the University of Texas, Dallas have done with *Polycraft World* (Smaldone, 2017). Modded from the popular game *Minecraft*, by Mojang, players use principles of organic chemistry to create complex polymers from simple monomers. Sometimes the scientist and game developer are one and the same. Melanie Stegman is a biochemist who studied the molecular causes of brain cancer, birth defects, and tuberculosis until she went full-time into game development. She founded

Molecular Jig Games, where she and her team of scientists and developers make such games as Immune Defense. Stegman was frustrated by the fact that when people would ask about her research, they would not understand the answers; her mission now is to help those people understand through games. “When I talk to people about cells and receptors, I want them to say ‘Which receptor?’ instead of ‘What is a receptor?’” She also created and runs the popular Science Game Center website (<http://www.sciencegamecenter.org/games>) where over 115 science games can be found. Stegman’s energy and enthusiasm for making science games is infectious. And that enthusiasm is becoming more evident among the growing ranks of scientists who are morphing into indie game developers (Kwok, 2017).

The number of independently developed games has exploded in recent years. However, the process of making and distributing games is costly. The availability of grants and new funding models such as online crowd-funding sites help offset those costs for small studios, but even so, it is often a struggle, with game development becoming a labor of love. Brandon Pittser, Director of Marketing and Outreach at Filament Games, says, “Educational game developers face the same issues as commercial game developers, most of which can be traced back to funding. In terms of distributing educational games, the target customers are often formal educational environments like schools and libraries, which tend not to be flush with extra cash.”

Having said that, the market for serious games (those with a purpose other than pure entertainment) is growing. According to Eliane Alhadeff, owner of the Serious Games Market website (<https://www.seriousgamemarket.com>), “In the commercial arena, SG [serious

games] have gone mainstream. The worldwide educational game market now is in boom phase. Global, regional, and country market conditions are now extremely favorable for Serious Game suppliers.” This is echoed by Pittser: “A lot of major educational publishers are now tuned in to the fact that games can take their existing curricular offerings to the next level by simply adding some fun, surprise, and engagement without harming the pedagogical accuracy and credibility of the product. It’s a great way to keep students hooked and on-task with learning content.” Even the popular game *Assassin’s Creed Origins*, by Ubisoft Montréal, has an educational Discovery Tour edition. And serious games get serious attention from other quarters as well. There’s the non-profit Games For Change (G4C) organization in New York City, whose tagline says it all: “Empowering game creators and social innovators to drive real-world impact through games.” In fact, some of the games mentioned in this article have won awards at their annual G4C Festival. And then there’s BAFTA, the British Academy of Film and Television Arts, who in 2018 introduced a new Game Beyond Entertainment category for the British Academy Games Awards.

But how effective are educational games? Hundreds of studies have been conducted on the efficacy of video games in education. Results seem to vary and likely depend on the specifics of each game. Efficacy also depends on evaluation criteria and methodology as pointed out by Ke (2009), whose metadata analysis of 89 studies is intended to establish guidelines and a “best practices” approach for future studies. To my knowledge, only one botanical video game has been evaluated in a classroom setting with the results being published. The mobile game *Little Botany* (Jamonnak and Cheng, 2017) lets players grow their own plants based on real-time weather

data, anywhere in the world. In so doing, they learn about plant structure and function (respiration, photosynthesis, transpiration). Using a 5-point Likert scale ranging from strongly disagree to strongly agree, player ratings for various aspects of playability were high, averaging greater than 4.0.

Here are my suggestions for the elements needed in a stimulating game about botany:

- First, I'm a real fan of story in a game. Good examples of adventure games with strong narratives are *Gone Home* and *Tacoma* (both by The Fullbright Company), *Everybody's Gone to the Rapture* (The Chinese Room), *Firewatch* (Campo Santo), and *What Remains of Edith Finch* (Giant Sparrow). As it turns out, a solid story is important in learning as it maintains motivation, which is often a big problem in educational games (Padilla-Zea et al., 2013).
- Next, we need enticing graphics. For an educational game, this might mean using botanically accurate 3D models. But these are not easy to come by and would likely require custom-crafting. For example, the stunningly detailed models shown in Figure 3 are the work of Dariusz Andrulonis, a freelance 3D artist with a biological background. But botanical science can also be taught with imaginative, even cartoon-like, plants. For example, the whimsical 2D series of plants in Figure 4 by Olga Samoilova might be an excellent choice for a platformer game. It all depends on the mood that the game creators are trying to achieve.
- We also need a game design that promotes learning. Although there are many options here, I like the stealth approach. As one reviewer of *Solarium* put it, "They tricked me into learning." A good example of that



**Figure 3.** Botanically accurate 3D models of a Carboniferous forest created by Dariusz Andrulonis. (<https://dariuszandrulonis.artstation.com/>) for the education portal, *edukator.pl*. The scene took almost three weeks of intensive work to complete.

sort of subtlety is used in the game *Never Alone*, by Upper One Games. This puzzle-platformer shares the stories of Iñupiaq culture as entertainment, but cleverly revitalizes interest in Alaskan indigenous folklore.

So, what would be the story? Being a plant physiologist with an interest in plant-water relations, my first thought would be a game about the adventures of a water molecule. I think we would need to anthropomorphize a bit and give the molecule a personality and a name. So, Emma would wander within the plant after first entering the root from the soil, journeying to the leaves through the xylem and finally departing the plant to join her long-lost friends in the atmosphere. Along the way, Emma might help the plant grow by joining forces with other water molecules to increase turgor and push mightily on cell walls. Or she could be recycled from a leaf back to the roots again through the phloem, carrying dissolved sugars with her, perhaps frustrating her to no end. Or maybe she's torn to bits after wandering into a chloroplast and being caught in the process of photosynthesis (very nasty). We could imagine all kinds of sociological



**Figure 4.** *Fantasy 2D plants created by freelance artist, Olga Samoilova (<https://www.artstation.com/ollsamoilova>). The drawing took 64 hours to complete.*

undertones as Emma competes with all those other water molecules struggling to evaporate from the interior of the leaf (me first! me first!) and ultimately gains her freedom through transpiration.

And here's the paradox: designing a video game to be played indoors in order to promote botany which should take a person outdoors. One way to bridge that gap is to develop games which are used exclusively outdoors. For example, *Seek*, by iNaturalist, rewards players with badges for finding examples of plants, animals, and fungi, using image recognition technology to identify the player's uploaded photographs. For many years, paleontologist Scott Sampson was the host of *Dinosaur Train*, an animated television show teaching children about prehistoric life and environments (worth watching even as an adult). He has always been an advocate for getting out into nature, yet was part of a show that seemingly kept kids glued to a screen. In an interview (Becktold, 2016) about this, Sampson said:

"We're using technology to leverage nature connection. If that's where the eyes are, let's go there and promote this thing that's really good and important for kids." I agree.

Video games provide additional ways to communicate the beautiful science of plants. The advent of virtual reality (VR) and augmented reality (AR) will offer unprecedented opportunity to engage students and the public in all things botanical. "The new paradigms of immersion and interaction provided by these new mediums creates a new frontier in how we develop and interact with digital learning content, which is very exciting," writes Pittser. And it's already happening: *Tree*, by Milica Zec and Winslow Porter, is a brilliant new VR project which will finally give me the chance to see and feel what it's like to be a plant. As Stephen Jay Gould says in his 1993 book, *Eight Little Piggies*, "We cannot win this battle to save species and environments without forging an emotional bond between ourselves and nature as well—

for we will not fight to save what we do not love.” My hope is that the power of video games will ignite in others the same love of plants that was ignited in that 10-year-old boy in his garden so many years ago.

## LITERATURE CITED

Becktold, W. 2016. In Conversation with Dinosaur Train’s Scott Sampson. Sierra, The national magazine of the Sierra Club. <https://www.sierraclub.org/sierra/2016-5-september-october/mixed-media/conversation-dinosaur-train-s-scott-sampson>. Accessed August 30, 2018.

Blackhall-Miles, R. 2015. We need a cure for plant blindness. *The Guardian*. <https://www.theguardian.com/lifeandstyle/gardening-blog/2015/sep/17/we-need-a-cure-for-plant-blindness>. Accessed October 10, 2018.

Cooper, S., Khatib, F., Treuille, A., Barbero, J., Lee, J., Beenen, M., Leaver-Fay, A., Baker, D., Popović, Z., and Foldit players. 2010. Predicting protein structures with a multiplayer online game. *Nature* 466: 756–760.

Cowley, B., Charles, D., Black, M., and Hickey, R. 2008. Toward an understanding of flow in video games. *Computers in Entertainment* 6(2): Article 20.

Csikszentmihályi, M. 1975. *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play*, San Francisco: Jossey-Bass. ISBN 0-87589-261-2

Dugan, F. M. 2016. Shakespeare, Plant Blindness and Electronic Media. *Plant Science Bulletin* 62: 85-92.

ESA, 2018. <http://www.theesa.com/about-esa/industry-facts/>. Accessed October 10, 2018.

Higgins, A. 2018. The horticulture industry’s age problem is bigger than you think. *Washington Post*. [https://www.washingtonpost.com/lifestyle/home/the-horticulture-industrys-age-problem-is-bigger-than-you-think/2018/08/05/3c7d3618-734f-11e8-805c-4b67019fcfe4\\_story.html?noredirect=on&utm\\_term=.c6f36926f02a](https://www.washingtonpost.com/lifestyle/home/the-horticulture-industrys-age-problem-is-bigger-than-you-think/2018/08/05/3c7d3618-734f-11e8-805c-4b67019fcfe4_story.html?noredirect=on&utm_term=.c6f36926f02a).

Jamonnak, S. and Cheng, E. 2017. Little Botany: A mobile game utilizing data integration to enhance plant science education. *International Journal of*

Computer Games Technology. Article ID 3635061. <https://doi.org/10.1155/2017/3635061>

Ke, F. 2009. A qualitative meta-analysis of computer games as learning tools. In R. E. Ferdig (Ed.), *Handbook of Research on Effective Electronic Gaming in Education*, pp. 1-32, New York: IGI Global.

Kwok, R. 2017. Game On. Scientists are designing board, card and digital games to convey scientific concepts. *Nature* 547: 369-371.

Limelight Networks, 2018. <https://www.limelight.com/resources/white-paper/state-of-online-gaming-2018/>. Accessed October 10, 2018.

McGonigal, J. 2011a. *Reality is Broken. Why Games Make Us Better and How They Can Change the World*. Penguin Books, London.

McGonigal, J. 2011b. FORA.tv. <https://www.youtube.com/watch?v=liE2czrG0MI>. Accessed August 24, 2018.

Padilla-Zea, N., Gutiérrez, F. L., López-Arcos J. R., Abad-Arranz, A., and Paderewski, P. 2014. Modeling storytelling to be used in educational video games. *Computers in Human Behavior* 31: 461-474.

Smaldone, R. A., Thompson, C. M., Evans, M., and Voit, W. 2017. Teaching science through video games. *Nature Chemistry* 9: 97-102.

Wandersee, J.H. and Schussler, E.E. 2001. Toward a Theory of Plant Blindness. *Plant Science Bulletin* 47: 2-8.

Wikipedia, 2018. [https://en.wikipedia.org/wiki/List\\_of\\_video\\_game\\_genres](https://en.wikipedia.org/wiki/List_of_video_game_genres). Accessed August 24, 2018.

# Student Team-Based Tree Canopy Biodiversity Research in Great Smoky Mountains National Park

## PROJECT OBJECTIVES

The objectives of this field research project included: the first comprehensive survey and inventory of tree canopy biota, including Myxomycetes, macrofungi, lichens, mosses, liverworts, ferns, green algae and cyanobacteria, formerly known as blue green algae, myxobacteria, insects, and mollusks in Great Smoky Mountains National Park (GSMNP); to search for and collect myxomycete species new to science and document new records for the park; compare the assemblages of tree canopy life forms on the bark of different living tree species with targeted groups occurring on ground sites; assemble a diverse team of experts who will collect, identify, and curate the targeted organisms; provide mentorship and publication experiences for undergraduate and master degree students which will enhance their opportunities for postgraduate

study and future careers; involve volunteers, park interns, teachers, citizen scientists, and students in interpretative exhibits, news media coverage (print and television), publication of articles in popular magazines, newsletters, and in peer-reviewed journal articles that will send a powerful message for conservation and biodiversity; prepare and present posters and power point talks at local, regional, national, and international professional meetings (Keller, 2004).

## PROJECT DESIGN PHASES

This research project emphasized three phases: the *Adventure Phase* (instruction and application of rope-climbing techniques to access and sample from the tree canopy); the *Laboratory Phase* (isolation, identification, database management, and statistical analyses of tree canopy biota using moist chamber cultures and other techniques); and the *Publication Phase* (students published in newsletters and peer-refereed journals and gave oral and poster presentations at local, regional, national, and international professional meetings (Keller, 2004; Kilgore et al., 2008)).



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## STUDENT RECRUITMENT

Informational flyers were posted around the University of Central Missouri (UCM) campus and distributed at annual conferences that described the objectives, the rope-climbing school, course requirements, financial support, availability of research and teaching assistantships, faculty involved in mentorships, and website access with scenic photographs of the study area. Announcements were published in national newsletters. Presentations were given by project leaders and students at departmental seminars, at student orientations, and in biology courses that highlighted research results and professional activities.

Interview questions determined student interest relative to the three project phases and emphasized experiences beyond just research, such as travel opportunities, professional and academic networking, international collaboration, media and outreach activities, and grant writing and fundraising experience. Student selection included review of transcripts and coursework in biology, a written essay expressing interest in field ecology research, letters of recommendation, and a personal interview. Interviews included assessment of student ability to follow instructions and safety protocols, foster team spirit with a cooperative attitude, and the interpersonal skills essential for a large collaborative effort. Prior field experiences such as hiking, backpacking, and rock or wall climbing and camping, especially in remote areas, was an additional consideration in reviewing applicants. Extracurricular activities were also important, including relevant skills obtained in team sports, 4-H projects, farm or ranching experiences, small business activities (paper route was one example), and leadership positions as well as skills such as use of computer software,

microscopes, digital cameras, topographical maps, global positioning systems, and future career interests, especially graduate school (Keller, 2005).

## STUDENT ENROLLMENT IN COURSES

Each student was required to enroll in BIOL 4011, Special Problems in Biology Research, for one credit hour. This included preparing a journal of each day's field activities and at the end of the trip a paper organized into sections (Introduction, Methodology, Results, Conclusions, and Epilogue) prompted by a series of leading questions. A few examples of these questions were: Why was the GSMNP selected as the study site area? Describe the advantages and disadvantages of the double rope-climbing technique? What are some of the discoveries you made in the tree canopy? Why did you want to participate in this research project? What did you learn about yourself from climbing and sampling from the tree canopy and living and working with other student team members? Based on your observations in the GSMNP, develop a series of questions or hypotheses used in laboratory experiments for the targeted organisms.

## TEAM SPIRIT, TEAM BUILDING, AND ESPRIT DE CORPS ACTIVITIES

Group activities after a hard day of climbing and collecting bark samples from trees helped to break the work routine, and included sorting bark samples; separating mosses, liverworts, and lichens; and preparing voucher herbarium specimens for the tree species. Everyone

pitched in to prepare and cook supper, enjoy a hot meal together, and wash dishes. Free time, especially on rainy days, involved the ground crew, mostly university faculty botanists, who gave special lectures, slide shows, and field demonstrations on how to collect and identify the targeted organisms. This helped the students learn how to recognize what they observed in the tree canopy (Keller et al., 2005).

Field research teams that play together, stay together—and this helped to develop a special bond through teamwork. These group activities involved playing card games; throwing and catching baseballs, softballs, and Frisbees; and tossing yard darts. The students also prepared a group supper for volunteer park personnel, park interns and rangers, and friends who assisted us on the trails.

Some students on their days off would hike and bike into the backcountry to enjoy the scenic wonders of the Smokies, such as the flaming azaleas at Gregory Bald and the Cades Cove loop road, observe spectacular waterfalls (Abrams Falls, Grotto Falls, and Laurel Falls), see the synchronous fireflies, enjoy the thrill of water rafting, or just relax and read. Kenny Snell collected myxomycetes at night with a flashlight and discovered tiny myxomycete fruiting bodies in various stages of development that glistened and became more conspicuous at night on the underside of decaying logs (Keller and Snell, 2018). These nighttime flashlight forays resulted in the first-time observations of slugs feeding on the immature fruiting body stages of myxomycetes published in the journal *Mycologia*, with the digital image of the slug eating the myxomycete selected for the front cover artwork (Keller and Snell, 2002).

Melissa Skrabal designed and sketched our tree canopy biodiversity logo, which was



**Figure 1.** *Tree canopy biodiversity logo made into a cloth patch; color sketch by Melissa Skrabal. Photo credit HWK.*

made into a cloth patch to provide research team members, volunteers, park personnel and interns, newspaper reporters, family and friends with a memento of our tree canopy biodiversity research project. This logo recognized the support of the National Science Foundation and Biodiversity Surveys & Inventories Program and our home institution Central Missouri State University (now UCM). More than 100 of these patches were distributed and posted on bulletin boards, worn on blazers and jackets, and identified gear bags or backpacks (Fig. 1; Kilgore et al., 2008).

## WHY WAS GREAT SMOKY MOUNTAINS NATIONAL PARK SELECTED AS A STUDY AREA?

The park includes more than 210,000 ha and serves as a refuge for one of the richest and most diverse biotas in a temperate region of the world. It contains the largest remaining



## TREE-CLIMBING SCHOOL, SAFETY PROTOCOLS, AND LOGISTICAL SUPPORT

tracts of old-growth forest in the United States of America estimated at 40,000 ha, and was designated a National Park on June 15, 1934, an International Biosphere Reserve on October 26, 1976, and a World Heritage Site on December 6, 1983. It is home to a variety of forest types including spruce-fir, northern hardwood, pine-oak, hemlock, and cove hardwood with an elevation gradient from 263 to 1994 m. In addition, abundant year-round rainfall averaging 216 cm annually with moderate temperatures from 4° to 23°C provides ideal growth conditions for cryptogams. A new research initiative, the All Taxa Biodiversity Inventory (ATBI), was started in 2000 under the rubric of a non-profit organization, Discover Life in America (DLIA). It was the first attempt to inventory all life forms in any American national park (Fig. 2; Keller and Barfield, 2017).

A two-day climbing school was held at Pertle Springs on the UCM campus with a professional arborist as the instructor. Each student had to be over the age of 18, have medical insurance, and was required to sign a Release and Acknowledgment of Risks Agreement prior to attending the tree-climbing school. Contact information was provided in case of medical emergency as was optional information regarding any physical condition that might increase the risk of being in the field for prolonged times and the endurance required to hike long distances and to climb trees. Safety precautions and safe climbing protocols were emphasized throughout this tree canopy research project.



**Figure 2.** Scenic Cades Cove valley where the project lodging was located.  
*Photo credit HWK.*

Park personnel helped in obtaining collecting permits issued by the U. S. Department of Interior, provided topographical maps marked with trails that had champion-sized trees, and gave briefing sessions on proper conduct in the park. DLIA provided cabins equipped with beds, a kitchen, showers, a washer and dryer, and computer outlets.

## PROJECT CHALLENGES

Our greatest challenge was stormy, rainy weather with lightning strikes, which posed serious safety hazards. Weather forecasts in the GSMNP were unreliable since they were not precise for any specific regions of the park. Because it is so large, it frequently rains heavily in one part of the park with little or no rain in other parts. At lower elevations, movement of storms was seen at farther distances, and this allowed the climber ample time to complete work and exit the tree. Higher altitudes made it difficult to tell exactly how far away a potential storm was located because of mountain ridges blocking long-range views. Furthermore, rain is also a hazard because wet ropes are more likely to slip, tightening knots, and making ascent more difficult. Wet branches reduce traction, making it more difficult to climb and move within the tree. Ground sites become wet and slippery, increasing the chance that a climber or ground crew member would fall. Climbing just before, during, and after thunderstorms was avoided due to safety concerns (Kilgore et al., 2008).

## SPECIAL MEDIA HIGHLIGHTS

National Geographic Television produced two films, “BioBlitz Rock Creek Park 2007” and “Smoky Mountains Treetop Exploration,” that appeared as part of the Wild Chronicles series on Public Broadcasting Stations (PBS)

nationwide. The former was Episode #236, from August, 2007 and shot in Washington D.C. at Rock Creek National Park, and the latter was Episode #318 from February, 2008 and shot in GSMNP (North Carolina and Tennessee) with running times of seven minutes for each episode. Boyd Matson was the host and program narrator. These films featured UCM women climbers demonstrating climbing and bark sampling. In Episode #318, the storyline documented the exploration of the tree canopy in GSMNP using the doubled rope climbing method by student climbers Sydney Everhart and Courtney Kilgore, who demonstrated how to access, climb, and gather tree bark samples.

Newspaper reporters interviewed student climbers and wrote articles about the project; these were published in the *Washington Post*, the *Kansas City Star*, the *Maryville Times*, the *Mountain Press*, the *Tennessean*, the *Knoxville News-Sentinel*, the *Daily-Star Journal*, (Warrensburg, Missouri), *UCM Today* alumni magazine, and the *Muleskinner* (UCM student newspaper). Some of these articles appeared on the front page under banner headlines and went out on the Associated Press Wire Service.

## OUTREACH ACTIVITIES AND STUDENT MENTORING OPPORTUNITIES

The NSF Research Experience for Teachers Program grant financially supported Trish Smith, a Warrensburg Middle School 7th-grade life science teacher, and her students in a tree canopy study at Pertle Springs on the UCM campus. This research project involved UCM faculty and students who mentored the students in field collection of tree bark samples and monitored the preparation and

observation of moist chamber bark cultures in the laboratory. This provided mentorship opportunities for female UCM students who helped students detect and identify many different life forms in moist chamber cultures (Smith and Keller, 2004).

## STUDENT ACHIEVEMENTS

**Kenny Snell** conducted the first tree canopy study during the summers of 2000 and 2001 to characterize myxomycete (slime mold) communities using the doubled rope-climbing method in GSMNP. Most myxomycete species had an optimum pH and were obtained from all heights from 3 to 24 m based on bark samples collected from living trees cultured in moist chambers. The standard practice of collecting bark samples from living trees at about 3 m will recover the majority of myxomycete species cultured in moist chambers. Thirty myxomycete species new to the park were recorded from the tree canopy (Snell and Keller, 2003; Snell et al., 2003; Keller, 2004). A departmental, college, and university review panel recognized Kenny Snell with the two highest awards a graduate student can receive at UCM: first place for the Graduate Student Thesis Award and first place for Outstanding Graduate Scholar Award. He currently is an instructor at Metropolitan Community College, Kansas City Missouri and teaches botany, environmental science, and genetics.

**Melissa Skrabal** discovered a new myxomycete species, *Diachea arboricola*, on July 4, 2000 high in the tree canopy of a living White Oak tree in the Cades Cove area of GSMNP (Fig. 3). Plasmodial tracks (veins of the slime plasmodial stage) were found on the bark surface along with mature stalked sporangia in perfect condition, extending from 10 to 24 m.



**Figure 3.** *Melissa Skrabal with climbing gear collecting bark samples from the canopy of a live white oak tree #88. Photo credit HWK.*

This observation of plasmodial tracks up to 24 m with scattered sporangia forming along the way had never been described and published. Tiny stalked sporangia (1–1.3 mm in total height) were collected from the crevices and fissures of the bark exposing their glittering, iridescent, silvery-golden outer surface and basal spectral rainbow colors of the spore-containing spheres (Fig. 4). She observed the bright yellow phaneroplasmodial stage with a network of trailing plasmodial veins and described subsequent development of sporangial formation from bark culture in moist chambers (Keller et al., 2004; Keller, 2005; Keller et al., 2009). She graduated in 2001 from Central Missouri State University, *Magna Cum Laude*.



**Figure 4.** *Stalked iridescent sporangium of a new species of myxomycete Diachea arboricola.* Photo credit KLS.

**Sydney Everhart** found that there was no association between percent cover of epiphytes and myxomycetes; however, she did demonstrate that bark pH was a major factor influencing a community of corticolous myxomycete species. Acidic tree bark had a specific group of myxomycete species that was different from species associated with near neutral tree bark. She concluded that some myxomycetes are restricted to bark with a narrow pH range whereas others are generalists occurring on a wide range of pH. Patchy distribution of myxomycetes was attributed to the small plasmodium characteristic of most corticolous species (Everhart et al., 2009; Everhart et al., 2008; Everhart and Keller, 2008). She received multiple awards for her tree canopy research including the Association of Southeastern Biologists (ASB) Research Award in Microbiology for the outstanding oral presentation and the Elsie Quarterman-Catherine Keever Award for the best ecological poster at the 2007 ASB annual

meeting, UCM Research Council's first place award for Outstanding Graduate Thesis, and Biology Department Outstanding Graduate Student Award. She earned her Ph.D. from the University of Georgia and is currently Assistant Professor/Quantitative Ecologist in the Department of Plant Pathology at the University of Nebraska-Lincoln.

**Courtney Kilgore's** research on myxomycete aerial reproductive structures is a canopy-first study of this type. Myxomycete communities were different on bark and pine cones of short-leaf pine as were communities on redbud bark and aerial seed pods, and common milkweed stems and follicles, coneflower stems and inflorescences, and *Yucca* stems and follicles. Colonization patterns for the herbaceous perennial prairie plants occurred within a year and were distinct enough to warrant the coinage of a new habitat term, herbicolous, for these myxomycetes (Kilgore et al., 2009). Her climbing knowledge, application of safety protocols, and athletic skills using the double rope-climbing method were highlighted in *JBRIT* (Kilgore et al., 2008, 2009). She received the UCM Nahm Award for the Outstanding Graduate Student from the UCM College of Science and Technology. A photograph of her collecting bark samples in the tree canopy was on the front cover of the July 2008 issue of *Southeastern Biology* journal. The Mycological Society of America (MSA) held their annual meeting (2008) at Pennsylvania State University, and each year there is a t-shirt design contest open to all MSA members. Courtney submitted a black-and-white pencil sketch that was selected as the contest winner. Four edible mushroom cultivars were included in the winning design: Shiitake, Hen of the Woods, Portabella white variety, and the velvet foot mushroom with four mold species adorning the outer edge

(Fig. 5). She currently is an instructor of botany and biology at Robeson Community College, Lumberton, North Carolina.

**Erica Parker** studied the relationship between pH and myxomycete communities on bark of five living tree species at Big Oak Tree State Park, Missouri. She found that American elms with a neutral pH of 7.0 had a distinct group of corticolous myxomycete species and bald cypress with a more acidic pH of 4.6 had a different group. She represented the Department of Biology and her McNair Scholar's paper received the first-place award. She graduated *Cum Laude* in 2004 from UCM (Parker and Keller, 2003).

**Angela Scarborough** collected bark samples from the tree canopy at high elevation sites (about 1800 m) in the Clingmans Dome area of GSMNP from Fraser fir and red spruce, both with a pH near 4.0. These species are gradually declining and dying apparently due to acid deposition and aerial pollution. Fraser fir harbored no myxomycete species, whereas red spruce had the lowest mean bark pH and a distinctive assemblage of myxomycete species. Eastern red cedar, sampled at low elevation sites in GSMNP and Warrensburg, had a pH near neutral, with the highest myxomycete diversity of any tree species studied (Keller et al., 2009; Scarborough et al., 2009). Competing against graduate students at the ASB 2006 annual meeting held in Gatlinburg, Tennessee, she won first place for the outstanding microbiology oral presentation and first place for the best ecology poster, the Elsie Quarterman-Catherine Keever award. She also received the UCM Sigma Xi best undergraduate student paper award, the UCM Department of Biology and Earth Science Undergraduate Research award, as well as the UCM Distinguished Student Writer based on her tree canopy biodiversity paper (Scarborough et al., 2009).



**Figure 5.** *Illustrated fungi, mushrooms, and molds t-shirt design.*

## CONCLUSIONS

This tree canopy research project (years 2000–2008) resulted in 28 peer reviewed papers, 12 newsletter articles, 28 oral presentations, and 30 poster presentations at professional meetings, including the International Congress on the Systematics and Ecology of Myxomycetes, Association of Southeastern Biologists, Mycological Society of America, and Missouri Academy of Sciences. More information is available at <http://www.brit.org/HKeller>, and PDFs are available from the author. Traditionally males have dominated field research in ecology, but in this tree canopy study, females dominated.

## ACKNOWLEDGMENTS

This tree canopy study would not have been possible without the financial support of the National Science Foundation, National Geographic Society Research Committee, Discover Life in America, Missouri Department of Natural Resources, Sigma Xi, The Scientific Research Honor Society, and United States Department of Education McNair Scholars Program. Thanks go to many others who helped us in countless ways.

This research project was a team effort involving undergraduate and master's degree students and faculty research mentors from the University of Central Missouri (UCM) and other universities. Student participants who published papers in peer-reviewed journals were: Sydney E. Everhart, M.S., Courtney M. Kilgore, M.S., Kenneth W. Snell, M.S., Erin E. Fanning, B.S., Erica E. Parker, B.S., Angela R. Scarborough, B.S., Melissa S. Skrabal, B.S. (arranged alphabetically with graduation degrees).

## LITERATURE CITED

- Everhart, S. E., J. S. Ely, and H. W. Keller. 2009. Evaluation of tree canopy epiphytes and bark characteristics associated with the presence of corticolous myxomycetes. *Botany* 87: 509–517.
- Everhart, S. E., and H. W. Keller. 2008. Life history strategies of corticolous myxomycetes: the life cycle, fruiting bodies, plasmodial types, and taxonomic orders. *International Journal of Fungal Diversity* 29: 1–16.
- Everhart, S. E., H. W. Keller, and J. S. Ely. 2008. Influence of bark pH on the occurrence and distribution of tree canopy myxomycete species. *Mycologia* 100: 191–204.
- Keller, H. W. 2004. Tree canopy biodiversity: student research experiences in Great Smoky Mountains National Park. *Systematics and Geography of Plants* 74: 47–65.
- Keller, H. W. 2005. Undergraduate research field experiences: tree canopy biodiversity in Great Smoky Mountains National Park and Pertle Springs, Warrensburg, Missouri. (Invited Paper). *Council on Undergraduate Research Quarterly* 25: 162–168.
- Keller, H. W., and K. M. Barfield. 2017. Great Smoky Mountains National Park: The people's park. *Fungi* 10: 44–64.
- Keller, H. W., S. E. Everhart, M. Skrabal, and C. M. Kilgore. 2009. Tree canopy biodiversity in temperate forests: exploring islands in the sky. (Special invited paper.) *Southeastern Biology* 56: 52–74.
- Keller, H. W., M. Skrabal, U. H. Eliasson, and T. W. Gaither. 2004. Tree canopy biodiversity in the Great Smoky Mountains National Park: ecological and developmental observations of a new myxomycete species of *Diachea*. *Mycologia* 96: 537–547.
- Keller, H. W., and K. L. Snell. 2002. Feeding activities of slugs on Myxomycetes and macrofungi. *Mycologia* 94: 757–760. [Color image of a slug feeding on immature myxomycete sporangia selected for the front cover artwork.]
- Keller, H. W., and K. L. Snell. 2018. Hunting and collecting myxomycetes at night with a flashlight. *Fungi* 11: 43–44.
- Kilgore, C. M., H. W. Keller, and J. S. Ely. 2009. Aerial reproductive structures on vascular plants as a microhabitat for myxomycetes. *Mycologia* 101: 303–317.
- Kilgore, C. M., H. W. Keller, S. E. Everhart, A. R. Scarborough, K. L. Snell, M. S. Skrabal, C. Pottorff, J. S. Ely. 2008. Research and student experiences using the doubled rope climbing method. *Journal of the Botanical Research Institute of Texas* 2: 1309–1336.

## ADDITIONAL RELATED PUBLICATIONS NOT CITED

Parker, E. E., and H. W. Keller. 2003. Correlation of pH with assemblages of corticolous myxomycetes in Big Oak Tree State Park. *Journal of the McNair Central Achievers Program, University of Central Missouri*. Vol. XII (Issue 1): 4–8. [Awarded first place by a university panel of judges.]

Scarborough, A. R., H. W. Keller, and J. S. Ely. 2009. Species assemblages of tree canopy myxomycetes related to pH. *Castanea* 74: 93–104.

Smith, P. A., and H. W. Keller. 2004. National Science Foundation Research Experience for Teachers (RET). *Inoculum* 55: 1–5.

Snell, K. L., and H. W. Keller. 2003. Vertical distribution and assemblages of corticolous myxomycetes on five tree species in the Great Smoky Mountains National Park. *Mycologia* 95: 565–576.

Snell K. L., H. W. Keller, and U. H. Eliasson. 2003. Tree canopy myxomycetes and new records from ground sites in the Great Smoky Mountains National Park. *Castanea* 68: 97–108.

Keller, H. W., S. E. Everhart, and C. M. Kilgore. 2017. The Myxomycetes: Basic Biology, Life Cycles, Genetics and Reproduction. *In*: Stephenson, S. and C. Rojas (eds). *Myxomycetes: Biology, Systematics, Biogeography and Ecology*, Chapter 1, pp. 1–40. Elsevier, Atlanta, GA.

Keller, H. W., P. Davison, C. Hauffer, and D. B. Lesmeister. 2003. *Polypodium appalachianum*: an unusual tree canopy epiphytic fern in the Great Smoky Mountains National Park. *American Fern Journal* 93: 36–41.

Keller, H. W., and C. M. Kilgore. 2008. Smoky mountains treetop exploration airs on Wild Chronicles. *Inoculum* 59(2): 47.

Keller, H. W., and M. Skrabal. 2002. Discovery of a new obligate tree canopy myxomycete in the Great Smoky Mountains National Park. *Inoculum* 53: 1–4.

Skrabal, M., K. L. Snell, L. Henley, J. Counts, and H. W. Keller. 2001. Fungi in the canopy - Great Smokies survey. *The Mycophile, Newsletter for the North American Mycological Association* 42: 6, 7, 13.



## PlantingScience's Spring Session is Underway!

As we get midway through the latest PlantingScience session, we have just under 236 student teams actively investigating seeds germination, photosynthesis, and agronomy. We love to brag about our scientist mentors on Facebook, but they really have been doing an amazing job this session. From encouraging students to consider why their predictions are what they are to providing extra resources, PlantingScience mentors have been hard at work training the next generation of plant scientists!

*Great hypothesis - I especially like that you have a good reason for saying your hypothesis, which is important! Hypotheses shouldn't just be guesses, but based on what's already known. And you used what you know about acid rain to make your hypothesis! (Nicole Soper Gorden, mentor extraordinaire)*

Our liaisons have been phenomenal as well keeping their teacher partners updated and helping them get their groups up and running. We have a few teachers who are new to the platform, so our liaisons have been doing an excellent job of keeping teachers, mentors, and students updated and on the same page. One thing that is clear this session is that liaisons and teachers now recognize mentors and are selecting the same mentors from previous session. Mentors and teachers alike are pleased!

*My name is Liming and I am the liaison for this project. As the start date is approaching, I wonder if there's anything I can help with, for example creating project teams? Otherwise if you can give me some information on the potential number of mentors needed, I can start to send out invitations. Look forward to this new semester! (Liming Cai, First-time PlantingScience Liaison)*



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

*BSA Science Education News and Notes serves as an update about the BSA's education efforts and the broader education scene. We invite you to submit news items or ideas for future features. Contact Catrina Adams, Education Director, at [cadams@botany.org](mailto:cadams@botany.org).*

All of the teachers who have participated previously on the current PlantingScience platform are enthusiastic and excited to be participating again. Many have posted in their forums something along the lines of "PlantingScience is one of the favorite projects for my students." We hope that the session continues to run smoothly for our teachers, students, mentors, and liaisons.





*I am Sharon Harris, the Botany teacher of 7 junior and senior young women who are curious about the world around them and anxious to start this project. Two of the students worked on The Power of Sunlight module last year with me in AP Biology and when I told them we were doing this, they couldn't stop telling the other 5 what a cool thing this was going to be. (Sharon Harris, PlantingScience Teacher)*

*Seeds and plants are not my expertise - so I'm happy to be working with you all! (now when we do our Plate Tectonics Unit, then I'm in my real wheelhouse!) Last year my students did some great projects and I can't wait to get started this year. (Sara Melman, PlantingScience Teacher)*

*I am so excited to start this project with you all! Thank you for dedicating your time to mentor my students. (Phalguni Desai, NEW PlantingScience Teacher)*

Finally, we are excited to be running a beta test of a new the plant pathology module, on which we worked with our APS partner to create a new module based on the paper from Hirsch et al. (2018) in *The American Biology Teacher*.

## LITERATURE CITED

Hirsch, R. Louis, Miller, Seth, and Halterman, Dennis. "An Inquiry-Based Investigation of Bacterial Soft Rot of Potato." *The American Biology Teacher*, Vol. 80, No. 8, pp. 594–599, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: <https://doi.org/10.1525/abt.2018.80.8.594>.

A Special Post–Botany 2019 Symposium

Sponsored by:



### Early-Career Innovators in Herbarium-Enabled Research and Future-Proofing for the Next Waves of Inventiveness

Thursday, August 1, 2019

7:30 am - 1:00 pm

Starr Pass, Tucson

This Society of Herbarium Curators-organized event at [www.botanyconference.org](http://www.botanyconference.org), co-sponsored by iDigBio, will provide a venue for eight current and recent NSF Postdoctoral Fellows to present their herbarium-enabled research and provide fresh opinions on how collections can position themselves and the specimens and data that they curate to produce maximum research relevance in the next waves of innovation. These eight participants will present on a range of collections-enabled research topics, including such topics as Plant Invasions, Plant Responses to Extreme Events, Sand-Entrapment by Plants, Plant Extinctions on Islands, Evolution of Floral Scent, Herbarium Genomics, Parasitic Plants, and Tropical Tree Diversity. The 25-minute research talks will be interspersed with whole-group discussions of ideas raised by the speakers.

Organized by: **Austin Mast**, Department of Biological Science, Florida State University and **Patrick Sweeny**, Peabody Museum of Natural History, Yale University  
Sign up for this symposia when you register for Botany 2019 at [www.botanyconference.org](http://www.botanyconference.org)

Cost: \$45.00 includes Lunch and Snacks



# STUDENT SECTION

## Roundup of Student Opportunities

It's that time of the semester where you start to compile every opportunity you want to apply to into one list. To make this easier for you, we have compiled a list of all the opportunities we know about.

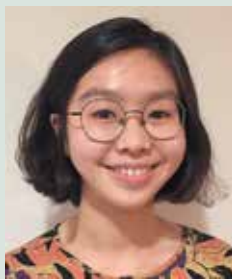
On the following pages, we have four categories for easy browsing that include the following: Grants and Awards, Broader Impacts, Short Courses and Workshops, and Job Hunting.

### GRANTS AND AWARDS

Grants and awards can help fund your research, provide assistance for travel related to training, fieldwork, or conferences, and even contribute to your cost-of-living and tuition expenses (e.g., fellowships). Additionally, applying for grants and awards is a great opportunity to hash out a research plan as well as fine tune your writing skills by articulating said research plan. Lastly, don't forget to check with your department and university to become familiar with internal grants that you can apply for!

### Grants and Awards Offered by BSA

Supporting student research is one of the most important missions of our Botanical Society of America, and starting from this year, **BSA increased the Graduate Student Research Awards from \$500 to \$1500!** This increase will make many impossible possible, and there are 20 total awards in 2019. Make sure to check out the "Awards" section on [www.botany.org](http://www.botany.org) and pay attention to the deadlines.



**By Chelsea Pretz and Min Ya**  
*BSA Student Representatives*

**BSA Graduate Student Research Awards**  
Including the J. S. Karling Award

Amount: \$1500                      Deadline: Mar. 15                      Purpose: Research funds  
More info: <https://cms.botany.org/home/awards/awards-for-students/>

**BSA Undergraduate Student Research Awards**

Amount: \$200                      Deadline: Mid-Mar.                      Purpose: Research funds  
More info: <https://cms.botany.org/home/awards/awards-for-students/>

**BSA Graduate Student Research Awards Given by Sections**

Amount: \$500                      Deadline: Mid-Mar.                      Purpose: Research funds  
More info: <https://cms.botany.org/home/awards/awards-for-students/>  
You can also research out to your section leaders to ask about awards they are offering this year!

**BSA Student Travel Awards**

Including TRIARCH “Botanical Images” Student Travel Award and Awards Given by Sections

Amount: Variable                      Deadline: Mar-Apr                      Purpose: Travel to the conference  
More info: <https://cms.botany.org/home/awards/travel-awards-for-students/>  
You can also research out to your section leaders to ask about awards they are offering this year!

**Botany 2019 Travel Grants for Presenters from Developing Nations**

Amount: \$1000                      Deadline: Mar. 15                      Purpose: Travel to the conference  
More info: <https://cms.botany.org/home/awards/developing-nations-travel-grants.html>

**PLANTS Grants**

Amount: Variable                      Deadline: Mar. 1  
Purpose: Cover costs of travel, registration, food, and accommodation at the conference  
More info: <https://cms.botany.org/home/awards/travel-awards-for-students/plants-grants.html>

## GRANTS AND AWARDS OFFERED BY OTHER ORGANIZATIONS

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

Amount: \$34k per year + tuition aid

Deadline: Oct.

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

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

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

### Fulbright U.S. Student Program

Amount: Variable

Deadline: Oct.

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

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

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

### American Association of University Women (AAUW) Dissertation Fellowship

Amount: \$20,000

Deadline: Nov. 1

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

Purpose: Dissertation Fellowships offset a scholar's living expenses while she completes her dissertation. The fellowship must be used for the final year of writing the dissertation. Applicants must have completed all course work, passed all preliminary examinations, and received approval for their research proposals or plans by the preceding November.

More info: <https://www.aauw.org/what-we-do/educational-funding-and-awards/american-fellowships/>

### NIH Postbac Intramural Research Training Award (POSTBAC IRTA/CRTA)

Amount: One year stipend ~\$34k

Deadline: 6 months before intended start date

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

Purpose: Recent college graduates who are planning to apply to graduate or professional (medical/dental/pharmacy/nursing/veterinary, etc.) school an opportunity to spend one or two years performing full-time research at the NIH.

More info: [https://www.training.nih.gov/programs/postbac\\_irta](https://www.training.nih.gov/programs/postbac_irta)

**CIC Smithsonian Institution Fellowship**

Amount: \$36k for one year

Deadline: Nov.

Nationality/Affiliation requirement: Only students currently enrolled in one of the Big Ten Academic Alliance member universities are eligible.

Purpose: To support research in residence at Smithsonian Institution facilities. All fields of study that are actively pursued by the museums and research organizations of the Smithsonian Institution are eligible.

More info: <http://www.btaa.org/resources-for/students/smithsonian-fellowship>

**Ford Foundation Fellowship Programs**

Amount: \$24K-\$45K, for 1-3 years

Deadline: Dec.

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

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

More info: <http://sites.nationalacademies.org/pga/fordfellowships/index.htm>

**SMART Program**

Amount: \$25K-\$38K/year + tuition

Deadline: Dec.

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

Purpose: To increase the number of scientists and engineers in the DoD. The program is particularly interested in supporting individuals that demonstrate an aptitude and interest in conducting theoretical and applied research.

More info: <http://smartscholarship.org/>

**Torrey Botanical Society Fellowships and Awards**

Amount: Up to \$2500

Deadline: Jan. 15

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

Purpose: To support research/education of student members by funding field work, recognizing research in conservation of local flora/ecosystems, or funding course attendance at a biological field station.

More info: <http://www.torreybotanical.org/grants-awards/>

### Botany In Action Fellowship

Amount: Up to \$5000

Deadline: Dec. 20

Nationality/Affiliation requirement: Enrolled in a Ph.D. program at a U.S. graduate institution (U.S. citizenship is not required)

Purpose: To develop new, science-based plant knowledge and chronicles traditional knowledge of plants. BIA promotes interactive scientific education about the importance of plants, biodiversity, and sustainable landscapes.

More info: <https://www.phipps.conservatory.org/green-innovation/for-the-world/botany-in-action/call-for-proposals>

### The Lewis and Clark Fund for Field Research

Amount: Up to \$5000

Deadline: Nov.

Nationality/Affiliation requirement: open to U.S. citizens and residents wishing to carry out research anywhere in the world. Foreign applicants must either be based at a U.S. institution or plan to carry out their work in the U.S.

Purpose: To encourage exploratory field studies for the collection of specimens and data as well as provide the imaginative stimulus that accompanies direct observation.

More info: <https://www.amphilsoc.org/grants/lewis-and-clark-fund-exploration-and-field-research>

### ASPT Graduate Student Research Grants

Amount: Up to \$1000

Deadline: Feb. 28

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

Purpose: To support both master's and doctoral students conducting field work, herbarium travel, and/or laboratory research in any area of plant systematics.

More info: [www.aspt.net/award](http://www.aspt.net/award)

### Richard Evans Schultes Research Award

Amount: Up to \$2500

Deadline: Mar 30

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

Purpose: To help defray the costs of field work on a topic related to economic botany for students who are members of the Society for Economic Botany.

More info: <http://www.econbot.org/index.php?module=content&type=user&func=view&pid=50>

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

Amount: Up to \$1000

Deadline: Mar 15; Oct. 1

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

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

More info: [www.sigmaxi.org/programs/grants-in-aid](http://www.sigmaxi.org/programs/grants-in-aid)

### **The Exploration Fund Grant**

Amount: Up to \$2500

Deadline: mid-Nov.

Nationality/Affiliation requirement: Grant does not apply to Chinese citizens

Purpose: To encourage research focused on systematics; also, projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.

More info: <https://systass.org/grants-and-awards/srf/>

### **Garden Club of America Scholarships**

Amount: \$2500-\$8000

Deadline: Feb. 1

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

Purpose: To encourage research focused on systematics; also, projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.

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

### **P.E.O. Scholar Award**

Amount: Up to \$15,000

Deadline: Dec.

Nationality/Affiliation requirement: Must be a citizen or legal permanent resident of the U.S. or Canada

Purpose: To encourage research focused on systematics; also, projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.

More info: <https://www.peointernational.org/psa-eligibility-requirements>

### **Grants from the Wetland Foundation**

Amount: Up to \$1600

Deadline: Dec. 18

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

Purpose: To support wetland education and research

More info: [http://thewetlandfoundation.org/The\\_Wetland\\_Foundation/Wetland\\_Grants.html](http://thewetlandfoundation.org/The_Wetland_Foundation/Wetland_Grants.html)

### **National Geographic Young Explorers Grants**

Amount: Up to \$5000

Deadline: 10 months before proposed work

Nationality/Affiliation requirement: None

Purpose: Support research, conservation, and exploration-related projects consistent with National Geographic's existing grant programs. In addition, this program provides increased funding opportunities for field work in 18 Northeast and Southeast Asian countries.

More info: <https://www.nationalgeographic.org/grants/grant-opportunities/>

### **The Mohamed Bin Zayed Species Conservation Fund**

Amount: Up to \$25,000

Deadline: Feb.; June; Oct.

Nationality/Affiliation requirement: None

Purpose: To support from conservationists based in all parts of the world dealing with plant and animal species.

More info: <https://www.speciesconservation.org/grants/>

### **Research Fellowships/Awards from the Arnold Arboretum**

Amount: Up to \$10,000

Deadline: Feb. 1

Nationality/Affiliation requirement: None

Purpose: Multiple awards and/or fellowships are offered for undergraduate and graduate students with topics that focus on Asian tropical forest biology and comparative biology of woody plants.

More info: [www.arboretum.harvard.edu/research/fellowships/](http://www.arboretum.harvard.edu/research/fellowships/)

### **The Councils of the Linnean Society and the Systematics Association: Systematics Research Fund**

Amount: \$1000-\$1500

Deadline: Feb. 20

Nationality/Affiliation requirement: None

Purpose: To encourage research focused on systematics; also, projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.

More info: <https://systass.org/grants-and-awards/srf/>

### **Awards from New England Botanical Club**

Amount: \$1000-\$2000

Deadline: Mar 1

Nationality/Affiliation requirement: None

Purpose: To encourage botanical research in New England region.

More info: <http://www.rhodora.org/>

### **SSB Mini-Arts Grant**

Amount: Up to \$4000

Deadline: Nov. 15

Nationality/Affiliation requirement: None

Purpose: This is to fund young researchers to spend a summer or semester apprenticed to an expert in a particular taxonomic group or to enhance revisionary taxonomic and systematics research in novel ways.

More info: <https://www.systbio.org/mini-arts-awards.html>



### **SSB Graduate Student Research Awards**

Amount: \$1000-\$2000

Deadline: Fall

Nationality/Affiliation requirement: None

Purpose: Eligibility of this award to master's students in the first 2 years of their studies and PhD students in the first 4 years for students to work on systematic questions below and above the species level, molecular and morphological approaches, and issues of pattern and process.

More info: <https://www.systbio.org/graduate-student-research-awards.html>

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

Amount: \$5000-\$10,000

Deadline: Feb. 1

Nationality/Affiliation requirement: None

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

### **Society for the Study of Evolution Grants**

Amount: \$2000-\$3500

Deadline: Varies

Nationality/Affiliation requirement: None

Purpose: This society has a range of grants that service students pursuing evolutionary research.

More info: <http://www.evolutionarysociety.org/content/society-awards-and-prizes/graduate-research-excellence-grants.html>

### **Prairie Biotic Research Small Grants**

Amount: \$1500

Deadline: Varies

Nationality/Affiliation requirement: None

Purpose: Supports the study of any species in U.S. prairies and savannas.

More info: <https://prairiebioticresearch.org>

### **The Mohamed Bin Zayed Species Conservation Fund**

Amount: up to \$25,000

Deadline: Varies

Nationality/Affiliation requirement: None

Purpose: The Mohamed Bin Zayed Species Conservation Fund is a new and significant philanthropic endowment established to directly support the cause of species conservation. It is open to applications for funding support from conservationists based in all parts of the world dealing with plant and animal species.

More info: <https://www.speciesconservation.org/grants/>

## BROADER IMPACT OPPORTUNITIES

These are not just for NSF grants! Sharing your passion for plants and science with a wide range of audiences will help develop speaking skills as well as help you reconnect with why you decided to go to grad school after all.

### **PlantingScience**

- What it is:** A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
- What you can do:** Interact with grade school-to-college students online, as they work on plant-focused learning modules in the classroom.
- More info:** [www.plantingscience.org/](http://www.plantingscience.org/)

### **Science Olympiad**

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

### **Local Arboretums, Parks, Museums, and Herbaria**

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

## SHORT COURSES AND WORKSHOPS

These are a great way to learn new research skills, which can also be added to your CV or resume. Here are a few of the many options available to grad students for part of a semester or summer.

### Advanced Field Botany

Location: University of Idaho

Duration: 2 weeks in June

Application deadline: Apr.

Cost: ~\$2000

Intro: This course is open to upper division undergraduates and early career graduate students. From this course, you will gain valuable experience and botanical knowledge in the field. You'll also get acquainted with the flora of Idaho in the Inland Northwest.

More info: [https://www.webpages.uidaho.edu/dtank/AFB/Advanced\\_Field\\_Botany.html](https://www.webpages.uidaho.edu/dtank/AFB/Advanced_Field_Botany.html)

### Summer Short Course at the Arnold Arboretum

Location: Arnold Arboretum of Harvard University

Duration: June 5-12

Application deadline: Mar. 15

Cost: free; also provides funding for travel

Intro: This short course will bring together a group of instructors to lead a broadly integrative analysis of the structure and function of leaves. Topics to be covered will include organogenesis and morphogenesis, evolutionary history of leaves, leaf anatomy, leaf traits, ecophysiology, physiology, hydraulics, stomatal functioning, and gas exchange.

More info: <https://www.arboretum.harvard.edu/education/summer-short-course/>

### OTS Courses in Tropical Field Biology

Location: Variable

Duration: Variable

Application deadline: Variable

Cost: ~\$5000

Intro: Courses through the Organization for Tropical Studies (OTS) are a well-renowned way to spend a summer or semester in the field, learning about the biology of tropical ecosystems in Costa Rica and South Africa. Course offerings include Field Ecology, Tropical Biology, Tropical Ecology and Conservation, Systematics of Tropical Plants, Tropical Ferns and Lycophytes.

More info: [www.ots.ac.cr](http://www.ots.ac.cr)

### Functional Live Imaging of Plants

Location: Nagoya, Japan

Duration: May 21-30

Application deadline: Feb. 10

Cost: 500 EURO

Intro: The course will feature lectures along practical sessions and image analysis. Participants will rotate through five practicals, including nanosensors and imaging protein-proteins interactions at nanoscale, two-photon deep-tissue imaging and cell ablation, chemistry-enabled and time-gated imaging, 5D imaging of development, microfluidic-enabled functional imaging.

More info: <http://meetings.embo.org/event/19-plant-live-imaging>

### Molecular Evolution Workshop

Location: Marine Biological Library at Wood's Hole    Duration: Aug 1-11

Application deadline: Apr 12

Cost: Participants can apply for financial aid

Intro: This 10-day course features a series of lectures, discussions, and bioinformatics exercises. Included are sessions on phylogenetic analyses, population genetics analyses, databases and sequence matching, molecular evolution, and comparative genomics.

More info: [https://molevol.mbl.edu/index.php/Main\\_Page](https://molevol.mbl.edu/index.php/Main_Page)

### Internship Opportunities

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

Research Experiences for  
Undergraduates (REU)

[https://www.nsf.gov/crssprgm/reu/reu\\_search.jsp](https://www.nsf.gov/crssprgm/reu/reu_search.jsp)

Botanical Society of America    [jobs.botany.org](http://jobs.botany.org)

### **Master's/PhD/Post-Doctoral Opportunities**

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

EvolDir [www.evol.mcmaster.ca/brian/evoldir.html](http://www.evol.mcmaster.ca/brian/evoldir.html)

EcoLog <https://listserv.umd.edu/archives/ecolog-l.html>

### **Academic Teaching Positions**

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

Botanical Society of America [jobs.botany.org](http://jobs.botany.org)

AAAS Science Careers [jobs.sciencecareers.org/jobs/botany-plant-science](http://jobs.sciencecareers.org/jobs/botany-plant-science)

### **Government Positions and Non-Academic Jobs**

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

Government Positions [www.usajobs.gov](http://www.usajobs.gov)

[www.americajobs.com](http://www.americajobs.com)

Conservation Job Board [www.conservationjobboard.com/category/botany-jobs](http://www.conservationjobboard.com/category/botany-jobs)

## WHAT'S NEXT: LOOKING FOR A JOB IN BOTANY

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

### Use your University!

Many academic institutions have offices that focus on helping alumni succeed after graduation. Check with your department or institution for resources on job announcements, workshops focused on personal development (such as CV/resume writing or getting a teaching certificate), and networking opportunities.

## FROM THE *PSB* ARCHIVES

**60 years ago:** An article by Richard H. Goodwin introduces readers to the work of the Nature Conservancy, established under its current name in 1950.

“How many of us have had the disquieting experience of discovering our favorite collecting spot or study area disappear overnight, as it were, leveled by the bulldozer, dried up by ditching, filled in by dredging, deforested, polluted, vandalized, despoiled?”

“We can no longer assume that the countryside will remain ours, available and convenient for use in our teaching and research. The time has come when biologists must actively participate in a broad program aimed at preserving one of the basic tools of our trade—natural areas, in which biotic communities of all types may be studied and observed in the natural state. Not only should these areas include unique habitats for the protection of rare species, but they should also preserve wild spots located at reasonable distances from centers of population and educational institutions.”

-Goodwin, Richard H. “Vanishing Habitats and our Professional Responsibilities. The Program of the Nature Conservancy“ *PSB* 5(1): 5-6

**50 years ago:** The Spring Wildflower Pilgrimage was advertised. This year will see the 69th Pilgrimage April 23-27, 2019.

“The 19th Annual Wildflower Pilgrimage will be held in Gatlinburg, Tennessee and surrounding territory April 24-26, 1969. It is sponsored by the Botany Department of the University of Tennessee, the Great Smoky Mountains National Park, the Gatlinburg Chamber of Commerce, and the Gatlinburg Garden Club. Motorcades and trail hikes under expert leadership take you to areas where spring wildflowers grow in quantity and variety. Morning bird walks are a feature of each day’s activities. Special programs are arranged for photographers, and there is an opportunity to show one’s own slides.”

*PSB* 15(1): 9

# Establishing a BSA Student Chapter at Our University

During the junior year of our undergraduate career, we realized that there was not a single student organization that focused on botanical sciences, let alone plants. Over a year later, in Spring of 2018, we successfully established a Botanical Society of America student chapter at our university. Our efforts to implement this chapter were prolonged due to our university's slow processing time for registered student organization (RSO) requests.

Prior to our BSA chapter gaining official RSO status, we had the opportunity to participate in the planning and facilitating of University of Central Florida's (UCF's) first Plants Beyond Limits Symposium. Our involvement allowed us an opportunity to establish the organization in the plant science community, especially toward the UCF students who attended (Fig. 1).

Once we established the chapter, we were able to host a handful of events in the span of one semester. Our first meeting was aimed at getting familiar with our new members, making sure that we were as inclusive as

possible. The new members spanned a broad range of interests—from experienced graduate students studying ecophysiology to undergrads interested in sustainable farming. Our two subsequent meetings featured invited speakers, including Drs. Chase Mason and Jason Cavatorta, who discussed their career paths and current work. The combination of speakers provided both an academic perspective (Dr. Mason is a professor at UCF) and an industry perspective (Dr. Cavatorta runs EarthWork Seeds Inc.). We also hosted a graduate student panel with a diverse group of current graduate students for undergraduates to gain different perspectives on research and career prospects within the area. Finally, a Plant ID Arboretum walkthrough was hosted in combination with the UCF Arboretum. In addition to organized meetings, groups of members participated in local events including those hosted by the local University of Florida's Institute of Food and Agricultural Sciences (IFAS) branch.

Out of the whole process, one of the most rewarding aspects of establishing the BSA chapter was to see so many new faces with similar interests. In such a large institution, it can be easy to blend in with the thousands of students even within a department. Seeing a community form for botanical enthusiasts in front of our eyes as our new members mingled at the first meeting made the time spent establishing this chapter well worth it.

This year, three BSA chapter members were able to attend Botany 2018. In the future, the



By **Michelle L. Gaynor** (*University of Florida*),  
and **Simone Lim-Hing** (*University of Georgia*)



**Figure 1.** *Students at the Plants Beyond Limits Symposium, 2017.*

chapter hopes to raise funds through plant sales to help financially support attendance to the BSA annual meetings as well as provide small research grants. Although we both are now pursuing botany at new universities, we hope that this chapter will build a stronger and more diverse botanical community at UCF (Fig. 2).



**Figure 2.** *The UCF Chapter's BSA logo.*





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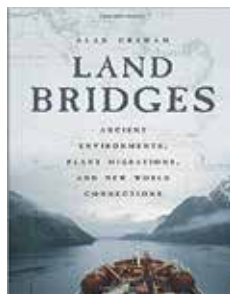
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## BIOGEOGRAPHY

### Land Bridges

Alan Graham  
2018, ISBN-13 9780226544298  
Paperback, \$50.00; cloth,  
\$150.00; 288 pp.  
University of Chicago Press,  
Chicago, IL



This year, Dr. Alan Graham published his fourth book on the vegetative history of the new world, this time focused on the physical connections that allowed for the migration of plants, animals, and ultimately humans between continents. Graham, Curator of Paleobotany and Palynology at the Missouri Botanical Garden, has spent most of his career studying neotropical angiosperm species through the Cretaceous and Cenozoic, and his expertise

on the subject is evident from the mere breadth of information provided in this new treatise on biogeography.

Land Bridges, clocking in at nearly 300 pages, is concise but dense, with an array of descriptions, figures, and a hefty online appendix. While the various lists don't quite make for easy fireside reading, they do underscore the utility of the book as a compendium for further furtive research on the part of the reader. In the preface, Graham notes that in a review for his previous book, *A Natural History of the New World*, the writer stated, "I found the numerous historical asides and personal anecdotes distracting (although to be fair I should acknowledge here that my graduate students had the reverse reaction and really enjoyed these parts)." The number of anecdotes and stories were thus "...reduced in the present text." As a graduate student myself, I offer the reverse critique (my only one for the book). The few stories that Graham does include are well-placed and told, such as

the expeditions of Vitus Bering (for whom the first land bridge discussed in the book was given its namesake) and the death of Alfred Wegener in Greenland (part of the North Atlantic Land Bridge). As someone who enjoys the storytelling aspect of science communication, I keenly felt the lack of other such stories and wish there'd been more.

For anyone considering purchasing this book, I offer the following barebones summary and description. According to Graham, the purpose of his previous three books was to outline the vegetation history and climate regimes of new world plants through time, whereas this book specifically tackles the subject of plant migrations across land bridges, starting with the advent of angiosperms in the Cretaceous. He recognizes five such land bridges, each the subject of its own chapter (with the exception of Beringia, which has two chapters): the Bering Land Bridge, the North Atlantic Land Bridge, the Antillean Land Bridge, the Central American Land Bridge, and the Magellan Land Bridge.

Each chapter is broadly organized into sections that deal with the physical description of each geographic area along with the associated climates, the historical geology with a special focus on how and when each land bridge formed and (in the case of some) eventually sank or broke apart, the modern vegetation, utilization of the land bridge by plants (a few animals get honorable mentions), and a final section on how humans used the land bridges, if at all. While Graham discusses fossil plants and their distributions throughout the text, he includes a chapter toward the end on a few case studies as an added bonus. Here, the biogeographic history of several families and genera (mostly angiosperms) is discussed at length.

Anyone who studies plant biogeography should have a copy of this book. The condensed and aptly summarized 100-million-year geological history, the descriptions of current day climates and ecosystems, the history of

floral migrations, and most valuable to the researcher, a voluminous list of citations and recommended reading make this an invaluable tome for future research and investigation. Graham puts it best in the book's conclusion:

“It is a long way from the Arctic to the Antarctic, and 100 Ma is a long time allowing for the probable and the improbable to occur. During this interval the Atlantic Ocean opened, separating the New World from Africa and Europe; mean annual temperatures varied by 3°–5°C in the tropics to 8°–15°C toward the poles; the Rocky Mountains, Sierra Nevada, and Andes Mountains rose; North America was joined by South America via the isthmus of Panama; the Gulf Stream strengthened, bringing greater heat to the North Atlantic; palms grew within the Arctic Circle; the Amazon River reversed its course from the Pacific to the Atlantic; South America and Antarctica separated with formation of the Magellan Strait, the Drake Passage, and the Antarctic Circum-Current; glaciers formed, plants disappeared, oceans cooled, and the cold Humboldt Current flowing northward added to the dryness developing along the west coast of South America; sea levels rose and fell by 150 m, alternately inundating then exposing coastlines and continental interiors; humans crossed Beringia for the first time, moving from Asia into North America; plants evolved new ecological tolerances and pollination, dispersal, and defense mechanisms; CO<sub>2</sub> concentration varied from more than 1000 ppmv (or perhaps capped at 1000 ppmv...) to less than 200 ppmv; and during all this time land bridges were modifying atmospheric and ocean circulation patterns and periodically joining the New World to and separating it from regions and biotas immediately adjacent and far beyond.”

*-Jerald B. Pinson, Department of Biology,  
University of Florida, Box 118525, Gainesville,  
FL 32611 USA*

## ECOLOGICAL

### **Twilight of the Hemlocks and Beeches.**

Tim Palmer

2018. ISBN 9780271079530

Hardcover, \$34.95; 171 pp.

Pennsylvania State University Press, University Park, PA



It is very difficult to approach writing about *Twilight of the Hemlocks and Beeches*, because pondering this topic is overwhelmingly sorrowful. The book's author and photographer, Tim Palmer, is a visual and verbal storyteller whose craft (this is his 27th book about the environment and adventurous travel) changes readers' understanding of the world. Here, he portrays two calamitous events. The approaching end to Eastern hemlock, a foundation species of pristine North American forests, is under threat now by the exotic invasive woolly adelgid, *Adelges tsugae*. Beech trees are likewise afflicted. Their disease occurs after extensive bark invasion by the beech scale insect, *Cryptococcus fagisuga*. Excessive feeding introduces two fungal species of *Neonectria* to produce annual cankers on the bark of the tree. The continuous formation of lesions around the tree eventually girdles it, resulting in canopy death.

The book's success in delivering his message is the result of splendid photographs used as a persuasive tool to deliver the conservation lesson, conferring urgency to his work. As an artist and photojournalist, he evokes sympathy for the societal and spiritual as well as the economic value of the trees he images. Palmer makes superb use of photography's potential for combining poetry with phenomenological accuracy to communicate the quality of place.

The author's introduction conveys the essence and feeling of the forest, using photography's potential for transmitting the symbolic and experiential qualities of environmental elegance; it "calls up a sense of reverence. In the trees' scented atmosphere, life is serene, soothing, protected." Combining poetry with phenomenological accuracy, Palmer helps us understand the relationship of hemlocks in our environment: "My footsteps are muffled by the softness of the needle-filled mattress underfoot, giving extra spring to my stride." He also states, "I can imagine the earth before we humans were born, a land governed by itself in wildness beyond anything we now know. Primeval."

This study reveals Palmer's unwavering attachment to the topography and psychology of landscape: his cherishing of unspoiled lands. His photographs are tools punctuating his remarks and attesting to the authenticity of his perception. They augment the ability of the written word to explain multiple layers of cause, effect, and significance using the evocative power of photographs to foster empathy and appreciation.

Involving our emotions as well as our intellect, Palmer's unretouched 105 documentary photographs force us to care about what has been presented and potentially to act to prevent their predicted demise, as he urges in the final chapter ("Confronting Loss and Welcoming Renewal") by dual means: biological control agents and chemical retardation. This volume is a compelling visual testament by a talented photographer that will appeal to many outdoor enthusiasts, natural historians, ecologists, and lovers of nature. Palmer's photographs inform us; they also touch our souls.

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

## ECONOMIC BOTANY

### **Monsters Under Glass: A Cultural History of Hothouse Flowers from 1850 to the Present**

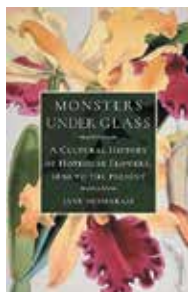
Jane Desmarais

2018. ISBN-13:

9781780239750

Hardback, £25.00; 248 pp.

Reaktion Books, London



#### “Monsters Under Glass”

by Jane Desmarais is a “cultural” history reference book that covers the history of how the fascination of exotics and tropical plants became prevalent in many classic novels, poems, and artwork. “Monsters Under Glass” covers not only the historical fascination, but also the rise of horticulture, horticultural cultivation techniques, glass innovations, and heating technologies. “Monsters Under Glass” refers to the greenhouse as a “hothouse”—hence, the historical background within the book on the rise of glass innovation and heating technologies as it plays a major role in the rise of exotic flower fascination. Since the cultivation of exotics outside the native region requires specialized care, specifically, they are best grown in a controlled environment that a greenhouse can provide; exotics are otherwise described as “hothouse flowers.”

Dating back to the early nineteenth century, the fascination with the hothouse and hothouse flower stimulated the imagination of artists, novelists, poets, and citizens of the era. Over about a 100-year span (1750 to 1850), approximately 5000 or more species of exotic plants were moved into England. A growing appeal with exotic plants and the gardening scene was first established and explored by the wealthy-class citizens. Affordable literature started to be published and public hothouses and botanical gardens expanded

in cities across Europe, allowing middle-class citizens to allure over the hothouse flowers. The expansion caused innovations in glass, in order to improve natural light inside hothouses, and new heating technologies permitted more even heating than the classic wooden stove previously provided. Over time, the rapid development of glass innovations in order to improve horticulture techniques moved away from being of avail to the wealthy class. Although glass innovations were moving at a significant rate, not everyone was fond of this swift advancement. In fact, some saw the glass innovations as only a modern fad and unrefined; Edgar Allen Poe, a classic American writer, stated that, “In the matter of glass, generally, we proceeded upon false principles. It’s leading feature is glitter.... unmeaning glass chandeliers, prism-cut, gas-lighted, and without shade, which dangle in our most fashionable drawing room, may be cited as the quintessence of all that is false in taste or preposterous in folly.”

From approximately 1850, increasing references throughout artwork, poems, and novels showed the captivation with the hothouse flowers. The hothouse and hothouse flower became powerful metaphors throughout novelists’, poets’, and artists’ work that widely varied in interpretations. Joel-Peter Witkins, a boundary-crossing photographer who idealized nature, expressed nature in the terms of beauty, sexuality, and decay. Witkins claimed that he wanted to “live in an age which sees similar beauty in a flower and in the severed limb of a human being.” Comparatively, H.G. Wells in his book “War of the Worlds” used red weed to metaphorically describe the dangers of colonialization. The metaphorical aspect in “Monsters Under Glass” shows how modern society draws on the fascination of the nineteenth century and hothouses, with coined terms like “intellectual

hothouses.” Beyond the metaphorical aspect, modern culture is just as fascinated with hothouse flower growth as in the nineteenth century. There is something gripping about the phenomena of containing wild nature under glass and the convergences of modern people to the blooming of the giant *Amorphophallus titanium*, better known as the corpse flower. The corpse flower rarely blooms and admits a stench that has been described as something reminiscent on rotting flesh and/or excrement. Despite the foul stench, large crowds gather to watch this exotic bloom.

Many other modern culture aspects are rooted deeply in this crazed nineteenth century culture of corsages and perfumes. The wearing of flowers (i.e., corsages) dates to the ancient Persian era, but the nineteenth century led to the exotic flower-wearing on the dandy male figure. The wearing of flowers, better described as a “flower fetish,” was a status symbol of wealth, individualism, admiration, and even homosexuality; carnations, violets, gardenias, poppies, and orchids were favored for flower-wearing. This “flower fetish” was not only in relation to the wearing of flowers, but also to the fixation with the fragrance produced by flowers, which similarly dates to the ancient Persian era. Throughout the centuries, perfume was used to combat fatal epidemic diseases such as the bubonic plague. The inhalation of odors was believed to offer protection against fatal epidemic disease, and physicians would disinfect the homes of the dead with strong scents and balms. The odors ranged from mint, cedar apple, violet, and roses. The nineteenth century was when the perfume industry changed dramatically, turning perfume into a luxury product that presented one’s social standing and character. The virtuous, wealthy, and women of good taste wore scents that were floral and dainty,

as opposed to the courtesans and prostitutes who wore scents that like jasmine (“musk like”), which hinted toward lust and earthy sexuality.

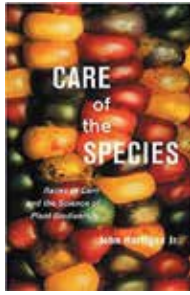
The association between social status and the fragrance worn by a woman is part of the long history of women symbolized by gardens and flowers throughout the centuries, which has appeared in classic artwork for interpretation amongst art viewers. Symbolisms can be a representation of a woman’s fertility, purity, innocence, devotion, sexuality, and natural beauty. Numerous types of flowers are within classic artwork, but the most commonly used over centuries is the rose and lily. The rose is a signifier of women in multiple different traditions, ranging from the standard symbol of femininity to sensual sexuality. The lily, by contrast, is represented as highly erotic and the profligate behavior in women. The rose and lily are representative of the sexuality of women throughout the centuries, yet the sexual connotations between these flowers is highly variably.

“Monsters Under Glass” compartmentalizes a long history into a short 217 pages while captivating the readers interest throughout its entirety. The author is a Senior Lecturer at the University of London. “Monsters Under Glass” is organized into 8 chapters, including 36 illustrations, 16 pages of references, and 6 pages of select bibliography.

--Erin Downey, *University of South Florida*

## Care of the Species: Races of Corn and the Science of Plant Biodiversity

John Hartigan, Jr.  
2017. ISBN 978-0816685356  
Paperback, \$20.00; cloth,  
\$108.00. 376 pp.  
University of Minnesota Press,  
Minneapolis, MN



trying to understand how they view diversity and species, how they study them, and how they relate to them and care for them. Hartigan begins this book with accounts of visits to laboratories where corn genetics and breeding is being studied in Mexico. He explores conceptual questions such as: what is a species? What is a “race” in corn? Are these human constructions? What is the use or value of these kinds of classifications? He also considers anthropocentrism and how it affects the ways these scientists think about and interact with their subjects. In discussing the concept of race as applied to plants, and how/why this diversity has been preserved (or not), he explores how the idea of racial identity as applied to humans and corn is intertwined in Mexico, and the problems with as well as uses of racial thinking.

The second half of the book moves to Spain where the author visits botanical gardens in Madrid, Barcelona, and Valencia. This section looks more broadly at how botanists think about and relate to plants, and how gardens make this accessible to the public. He talks with the botanists there about the process of classifying plants and how this affects their way of seeing and paying attention to plants. He explores broad questions such as: why do we care about plants and their diversity? How do we care for them or preserve that biodiversity? How do people (other than botanists) interact with botanical knowledge? For example, he describes the markers naming and classifying the plants in the gardens; the Spanish word for these markers is “etiquetas,” emphasizing the fact that these markers introduce visitors to the plants, just as our interhuman etiquette includes introducing each other in social situations.

The final chapter of the book, “How to Interview a Plant,” outlines exactly how Hartigan approaches an ethnographic study

The title of this book, taken on its own, might lead one to think that it is written by a biologist and that it will give a scientific review of the rich history of research on corn biodiversity. This would be an erroneous assumption, as this particular book explores the science of biodiversity from a very different perspective: that of cultural anthropology. Hartigan uses the tools of ethnography to examine ideas of race across species, the care of humans for nonhuman beings, and how our ideas about plants and diversity informs the way we think about conservation.

It seems that Hartigan began this work with the intent of doing an ethnography of the scientists working on corn biodiversity, in labs, botanical gardens, and seed banks. There is a rich body of work in cultural anthropology about scientists and the work of science, and the author has added to it with his work here. But somewhere along the path of the study, his focus shifted, and he ends up applying the tools and techniques of ethnography to the plants themselves, rather than the people studying the plants. In doing so, he raises some fascinating questions and asks us to look at plants differently even from how botanists may see them.

Throughout this book, Hartigan “follows the species” of corn as he visits laboratories, seed banks, and botanical gardens in Mexico and Spain where plant diversity is being studied and/or preserved, interviewing the scientists who work with the plants and

of a non-human species, going through step-by-step how one might “interview a plant.” His approach brings to mind the great botanist, P. Barry Tomlinson, who would often answer students’ questions about plants with the command, “Ask the plant!” In doing so, he directed our inquiry away from other scientists (who could be biased or flawed or, at the very least, restricted in their views of how plants work) and toward the organism in question, looking for answers directly from its biology. Hartigan approaches interviewing a plant systematically in the same way he would approach studying a particular human cultural group, and asks himself and other anthropologists as well as botanists: how do I observe, describe, ask questions of a plant? How do I apply the theoretical models of cultural anthropology to a completely different species? Essentially, this final chapter describes the methodology that Hartigan used in his studies of plants, developed after immersing himself in the world and thinking of botanists.

I am quite certain that, not being an anthropologist, I have missed much of the anthropological depth of this work, and I can’t even pretend to share that richness with you here. Instead, I offer the perspective of a botanist looking back upon the work of an anthropologist who studied botanists. I find the perspective refreshing and fascinating, even without the depth of context that an anthropologist would bring to the reading. Hartigan says in his introduction, “I hope the reader will find on these pages a variety of entry points for understanding plants and learning to recognize them in the world around us.” I think that he does this pretty well for those who are not botanists, combatting just a little the plant blindness we find so rampant among our own species. For botanists, on the other hand, he provides us with both an

anthropological view of our own kind as well as a glimpse of how those outside our field may receive our understanding of plants and way of seeing them.

-Amy E. Boyd

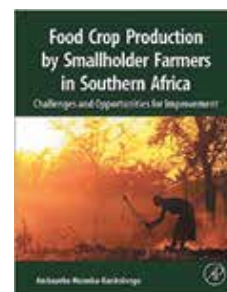
### Food Crop Production by Smallholder Farmers in Southern Africa: Challenges and Opportunities for Improvement

Ambayeba Muimba-Kankolongo

2018. ISBN 978-0-12-814383-4

Paperback, \$200.00. 368 pp.

Academic Press, Cambridge, MA, San Diego, CA



Muimba-Kankolongo, whose career spans 30 years assisting small-scale farmers in central and southern Africa, received his M.S. and PhD degrees from Cornell University and has been a contract instructor in the department of biology and biochemistry at Carleton University, Ottawa, Canada, and senior lecturer in the department of environmental and plant science, School of Natural Resources at the Copperbelt University, Kitwe, Zambia. His new textbook aims to fill a need for smallholder farmers in southern Africa. The volume opens with a sympathetic dedication to his mother who, he reports, was unhappy when he cleaned his plate, suggesting that he hadn’t had enough to eat.

Following the author’s introduction, topics covered include (1) Climates and agro-ecologies of the regional economic Southern African Development Community (SADC), that region comprising Angola, Botswana, DRC, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe; (2) Factors important to crop

production; (3) Crop diseases and pests; (4) Smallholding farms; (5) Common cultivation practices; (6) Pre- and postharvest field operations; (7) Cereal production; (8) Root and tuber crops; (9) Leguminous crops (beans, groundnuts, Bambara groundnuts); (10) Vegetable production (cabbage, okra, onion, pepper, pumpkins, rape, tomato); (11) Fruit production (banana, pineapple, sugarcane); and (12) Perspectives for improvement (seed quality, irrigation, storage structures, improving extension services).

Food Crop Production evaluates traditional cultivation practices used by smallholder farmers, adding the latest information on increasing crop yield through adoption of innovative techniques. It catalogs smallholder cultivation practices and recommends strategies for improvement, including management practices that reduce net carbon emissions and technologies that improve soil structures and conserve natural resources. Some attention is given to empowering women's contributions along value chains and urging government commitment to adopt policies that enhance agriculture productivity by encouraging farmers to use environmentally sound cultivation technologies.

Muimba-Kankolongo's specialty in plant pathology is pervasive throughout the textbook, in consideration of traditional farming techniques that have often produced negative impacts on the environment, resulting in crop vulnerability. Pests and diseases, weeds, and invasive plant species put populations at risk of poverty, hunger, and malnutrition. Food Crop Production

describes improved agricultural production technologies for ensuring adequate food production.

Although all photographs are not credited, numerous topical illustrations and a map enrich the textbook considerably. Tables taken from the U.S. Department of Agriculture provide nutritional values, per 100 g raw material of select local vegetables, including cabbage and okra. The contents are broad (i.e., include useful information, even about crop origins and geographical distribution); therefore, it should provide answers to most basic student questions.

The foreword by Dr. S. Nteranya, Director General, IITA, notes that this textbook was inspired by lack of such a resource for the Southern African region and includes the expressed hope that the information will be helpful to growers, research and extension services, and students and professionals in institutions of higher learning. He writes that while agriculture is at the core of local life, agricultural productivity for subsistence farmers has always been very low because of recurrent droughts, use of traditional farming systems, and outbreaks of pests and diseases. The book closes with a 14-page bibliography, a 4-page glossary, and a 15-page index. Its cost might be prohibitive, in terms of accessibility for student-farmers, hence it may be better described as a useful reference work.

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



## The Ethnobotany of Eden: Rethinking the Jungle Medicine Narrative

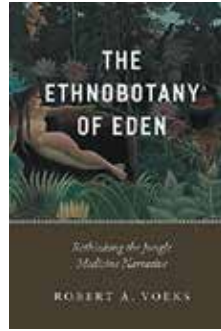
Robert A. Voeks

2018. ISBN: 9780226547718

Hardcover, \$45.00. 328 pp.

eBook ISBN: 9780226547855,  
\$10.00–\$45.00.

University of Chicago Press,  
Chicago, IL.



experience to tackle complex concerns such as the contentious issue of intellectual property, complicated by geography and time, writing that “intellectual ownership of botanical nature assumes many guises” (p. 116). As Voeks traces the colonial-era search for medicinal plants, he busts, repeatedly, the clichéd myth of the noble savage. Voeks views plant species that maintain more than one material value (e.g., as fiber and medicine or fiber and food) as rare.

Voeks’ lively writing style deserves praise too; notably, he can translate a biological process having a formidable designation, into language anyone can visualize. One example is this vivid description of cryptogeal germination using the “saxophone growth” metaphor: “Like many other palm species, piassava has the habit of sprouting immediately and abundantly after a fire. This is due to an unusual germination pattern, known as saxophone growth (cryptogeal germination), in which the terminal bud of the seedling initially burrows down into the soil, rather than reaching towards the sky. At about 20 cm in depth, it reverses course and pushes its leaves above ground. As a consequence, if the forest is cut and burned, the heart of the palm (apical meristem) is protected under the soil from the flames, allowing it to resprout a short while later. This feature is key to understanding how the species has been managed to the present day. When the density of the palm in an area is low, small patches of rainforest are cleared, sparing only adult piassava. The slash is allowed to dry, and then it’s burned. Within a few weeks, a near carpet of piassava seedlings emerge, having survived the heat of the flames safely ensconced below the surface. [...] Saxophone germination in palms now often points to deforestation and irrational exploitation, with isolated and unproductive palms in pastures and farm clearings marking “virtually dead” populations” (p. 40).

Robert Voeks, professor in Geography and the Environment at California State University, Fullerton, and the editor of the journal *Economic Botany*, reverses some romanticized notions about the profitable healing plant resources of tropical rainforests as “pharmaceutical factories.” Instead, Voeks shows that the medicinal Eden manifests its apothecary via a range of ruderal weeds, dominated numerically by disturbance, and pays homage to those folks whose experimentation led to their discoveries as nutrients and medicines.

Voeks’ analysis of tropical landscapes exemplifies the diverse topics to be found underneath the umbrella of the intersections amongst anthropology, botany, history, art, religion, and geography that form the discipline called ethnobotany. His descriptions are suspenseful, completely engrossing, to the degree that I had difficulty putting the book down. An example is his depiction of a secret stash of prized coffee seeds that was presented in a bouquet of flowers by the love-struck wife of a governor of French Guiana, Madam d’Orvilliers, to Brazilian sergeant Melo Palheta upon his departure. Those beans whisked off to Brazil were likely to have been the beans that led to Brazil’s eventual global dominance in coffee production, resulting in one of the world’s first examples of biopiracy.

Voeks’ own fieldwork in the tropics of Borneo, Brazil, and Mozambique provide firsthand

Scrupulous scholarship is in evidence, with 42 pages of references, 5 pages of notes, and the 18-page index, as well as the carefully credited variety of maps, digital photos, and illustrations. I observed only one spelling error, “recurring them[e] in ethnobotany” (p. 133). *Ethnobotany of Eden* is a benchmark contribution, with appeal to a wide audience of scholars and general readers holding interests in botany, conservation, tropical biology, economic geography, and environmental sciences.

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

### **Korean Functional Foods: Composition, Processing and Health Benefits**

Kun-Young Park, Dae Young  
Kwon, Ki Won Lee, and Sunmin  
Park, Eds.

2018.

Hardcover, ISBN

9781498799652, \$229.95. 564

pp.

eBook, ISBN 9781315156453, \$206.96

CRC Press, Boca Raton, FL.



Food is one key element of culture that presents opportunities for dissemination of cultural information. A recent title in the CRC Press series, *Functional Foods and Nutraceuticals*, features the health benefits and processing methods of Korea's major fermented foods such as kimchi, soybean paste, and red pepper paste, consumed with the traditional Korean dish, bibimbap. *Korean Functional Foods* serves as an essential scholarly resource, introducing readers to Korean culinary history since antiquity, including a focus on early myths.

The first chapters offer reviews of Korean food history, culture, and characteristics. Koreans

have created unique preparations as well as a food culture that is fundamentally distinct from Chinese or Japanese. Among their basic ingredients is bap, warm cooked rice, topped with small amounts of condiments (fermented side dishes and raw or broth-cooked vegetables and mushrooms), creating the colorful dish called bibimbap. The combination of vegetables, rice, fermented sauces and optional animal protein provides a balance of nutrients, rich in fiber. The primary cooking oils are from sesame, for its distinctive nutty aroma, and perilla.

Quintessential among Korean staple fermented foods is kimchi, a lactic acid bacteria fermented vegetable mixture. Although dozens of variations exist, the key ingredients of kimchi are Napa cabbage and radish, spiced with ground red pepper, garlic, ginger, and green onion, added to improve flavor, nutrition, and functionality. Kimchi decreases the pH of the colon environment, helping to maintain good colon health. Used for centuries as folk medicine, the investigated benefits of kimchi include antioxidant and antiaging, antimicrobial, antimutagenic and anticancer, anti-inflammatory alleviation of atopic dermatitis-like symptoms, anti-obesity, and cholesterol- and lipid-lowering effects.

This volume contributes to a rapidly growing body of literature covering the role of plant secondary metabolites in food and their potential effects on human health. Consumers, increasingly aware of diet-related health problems, seek natural ingredients that are safe, health-promoting nutraceutical components, including dietary fibers, phenolics, antioxidants, antimicrobials, and bioactive compounds. The healing properties of ginseng, vinegars, and spices including red pepper, ginger, garlic, black pepper, mustard, and sesame are evaluated herein.

## LITERATURE CITED

The editors provided a valuable service by assembling an extensive literature that will benefit

researchers with interests in public health, preventive medicine, dietetics, and nutrition. As is often the case with edited works, contributions are uneven, and there is a little duplication among chapters. Various assertions are outmoded; for example, although the axiom “Let food be thy medicine and medicine be thy food” is often attributed to Hippocrates as it is here, scholars no longer credit him. It seems that several chapters were written awhile before publication, because some information is not current; specific data are misleading (e.g., world crop production figures rely on a reference from 2005, rather than statistics that are updated annually). Many of the citations quoted in each chapter appear to be sourced from Korean, Japanese, and other Asian authors; therefore, relevant literature by other scientists might have been missed. In that spirit, it seems useful to correct the peculiar opening sentence of chapter 12 about sesame, positing that “sesame originated in Africa (or some species from India)”. Genetic, phytochemical, and molecular data amassed during four decades provide ample evidence that the crop species sesame (*Sesamum indicum* L.) was domesticated on the Indian subcontinent (Bedigian 1984, 2000, 2003, 2007, 2011, 2014, 2015; Bedigian et al., 1985; Gormley et al., 2015).

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

Bedigian, D. 1984. *Sesamum indicum* L. Crop origin, diversity, chemistry and ethnobotany. Ph.D. dissertation, University of Illinois, Urbana-Champaign. University Microfilms DA8502071, Dissertation Abstracts International 45, 1985: 3410-B.

Bedigian, D. 2000. Sesame. In K.F. Kiple and C.K. Ornelas-Kiple, Eds. *The Cambridge World History of Food*, Vol. I, pp. 411-421. Cambridge University Press, NY.

Bedigian, D. 2003. Evolution of sesame revisited: domestication, diversity and prospects. *Genetic Resources and Crop Evolution* 50: 779-787.

Bedigian, D. 2011 [2010]. Cultivated sesame, and wild relatives in the genus *Sesamum* L. Pages 33-77. In D. Bedigian, Ed. *Sesame: the genus Sesamum*. Medicinal and Aromatic Plants - Industrial Profiles series. CRC Press, Taylor & Francis Group, Boca Raton, FL.

Bedigian, D. 2014. A new combination for the Indian progenitor of sesame, *Sesamum indicum* L. (Pedaliaceae). *Novon* 23: 5-13.

Bedigian, D. 2015. Systematics and evolution in *Sesamum* L. (Pedaliaceae), part 1: Evidence regarding the origin of sesame and its closest relatives. *Webbia: Journal of Plant Taxonomy and Geography* 70: 1-42.

Bedigian, D., D. S. Seigler, and J. R. Harlan. 1985. Sesamin, sesamol and the origin of sesame. *Biochemical Systematics and Ecology* 13: 133-139.

Gormley, I. C., D. Bedigian, and R. G. Olmstead. 2015. Phylogeny of Pedaliaceae and Martyniaceae and the placement of *Trapella* in Plantaginaceae. *Systematic Botany* 40: 259-268.

## SYSTEMATICS

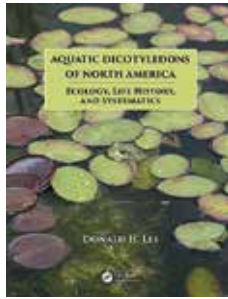
### **Aquatic Dicotyledons of North America: Ecology, Life History, and Systematics**

Donald H. Lee

2018. 978-1482225020

Hardcover: \$221.00 US; 1334 pp.

CRC Press (Taylor & Francis), Boca Raton, USA.



Because of their high productivity and essential role in filtering the ecosystem's water supply, wetlands are a central focus of ecological research and conservation efforts. To varying degrees, the plant components of their diverse communities are adapted to aquatic conditions, with submerged, emergent, free-floating, or suspended life forms found among fully aquatic species, while many other less specialized wetland taxa range widely in their tolerance of inundated conditions. Focusing on dicotyledonous plants considered obligatorily aquatic (i.e., requiring water to complete some essential stage of their life history), this authoritative book offers an encyclopedic compendium of their essential characteristics, ecology, and biosystematic position. It is not a guide for identification; there are no keys, photographs, or figures besides cladograms. Once the plants in question are identified, however, this work will serve as an essential reference on their backgrounds, distribution, community associations, phylogeny, and uses.

The book is organized taxonomically, using a recent Angiosperm Phylogeny Group classification scheme. Here the term dicotyledon simply refers to all non-monocot flowering plants, devoid of its former biosystematic status but evidently still useful. No reason is stated for excluding the

monocots, which are major components of aquatic communities, but one can surmise that another volume as enormous as the present one will be needed to treat them. Introductory information is given for families and genera that include aquatic species, and recent cladograms are provided wherever available, with aquatic taxa highlighted. Generic entries include etymology, synonymies, distribution, and species diversity (both globally and in North America), habitat characteristics, key morphological traits, life history details, and general biological and ecological characteristics. This is followed by a description of each relevant species, with their specific habitat preferences and ecological details. Included are lists of reported plant associates, sometimes extending to a half-page or longer, as well as known interactions with other kinds of organisms whose full taxonomic affinities are provided. Additional information on economic importance and any known medicinal or traditional uses are also given. Literature citations appear at the end of each genus entry. The list of cited references at the end of the book occupies almost 200 pages.

It is hard not to be impressed by a work of this magnitude and the sustained effort involved in assembling it. *Aquatic Dicotyledons of North America* appears destined to become an indispensable reference for almost any study of wetland plant communities on our continent and beyond.

*-William B. Sanders, Florida Gulf Coast University*

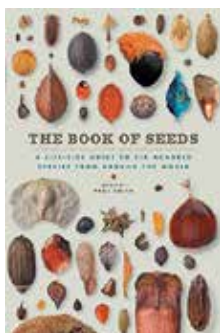
## The Book of Seeds: A Life-size Guide to Six Hundred Species from Around the World

Smith, P. (editor)

2018. ISBN-13: 978-0-226-36223-6 (cloth), 978-0-226-36237-3 (e-book)

Cloth, US\$55.00; E-book, US\$44.00; 656 pp.

The University of Chicago Press, Chicago, IL



Weighing in at nearly 2½ kg, *The Book of Seeds* contains actual- and magnified-sized illustrations of seeds from a taxonomic spectrum of 600 wild and cultivated species from around the globe. The high-quality images allow a reader to appreciate the intricacies of seed morphology—from the spiky surface of *Silene dioica* to the fiber network of *Telfairia pedata*. The bright red of *Abrus precatoris* seed or the mottled appearance of *Ricinus communis* seed leap from the page. The actual size of *Vanilla planifolia* seeds is so tiny that multiple seeds about the size of a dime need to be shown in contrast to *Lodoicea maldivica* seed that spans the bottom of 1½ pages—and this only shows the top-most part of the seed. From the two-horned seed of *Trapa natans* to the black-hair covered seed of *Protea cynarioides*, I believe a reader will be enthralled at all the textures, colors, sizes, shapes, and appendages of seeds that this book captures.

The heart of the book—covering about 95% of the 656 pages—is devoted to the seed guide. One species is covered per page. A world map with the geographical range, colored images of the seed, and a line drawing of the plant are shown for each species. Across the top of the page, the plant family, distribution, habitat, dispersal, conservation status, trivia notes, and seed size are provided. The text

is arranged in three short sections. The first contains information on the plant—its size, description, and uses—and the second covering similar species. The third section includes a mixture of data related to seeds and their production for the species (e.g., pollination, fruit structure, dispersal, moisture relations, and germination).

The other 5% of the book has introductory material and chapters devoted to seed biology (anatomy, morphology, dormancy, and longevity), seed plant evolution, seeds and humans, seed conservation (collection, storage, and germination), and the importance of plant diversity. Each of these chapters covers the relevant information in succinct detail. At the end of the book, a reader will find a glossary, list of resources, notes on the editor and five contributors, and two indexes—one with common names and the other with scientific names.

Without dwelling on every little detail, let me provide some examples of areas that I think the book could have been improved. Providing sources would have clarified information provided in the book. I realize that a popular book shouldn't overburden a reader with references. However, I assumed that the conservation status for each species was from the IUCN. I guess this was correct since very few inconsistencies occurred (e.g., *Pterocarpus santalinus* listed as Near Threatened and not as Endangered). Are seeds of *Oenothera caespitosa* and *Dionaea muscipula* bird dispersed? I searched in vain for literature but could not find any information to support these claims.

A reader needs to be careful with the geographical ranges of species given in the book. Some species have a narrower range than indicated in the book (e.g., *Jatropha*

*gossypifolia* grows only in Florida (not throughout North America) (USDA Plants, <https://plants.sc.egov.gov/java>). The ranges of other species are wider than indicated (e.g., *Fragaria virginiana* and *Oxalis violacea* occur throughout all or most of the United States, not only the Midwest). Naturalized ranges for some species are provided (e.g., *Ligustrum sinense*, *Nepeta cataria*), but those for other species are not (e.g., *Daucus carota*, *Lactuca sativa*). Some distributions are easily missed due to their extremely small size (e.g., *Alluaudia procera*). I would have placed an arrow to draw attention to the area.

Unfortunately, some statements on seed dormancy are misleading. The book states that "... it is only the weathering of the seed coat ... or by passing through the gut of an animal" that allows physical dormancy to be broken. On the contrary, this dormancy is also overcome by fluctuating temperatures, drying, fire, and winter temperatures. For physiological dormancy, "... seeds require cold temperatures [cold stratification] to break down inhibiting chemicals before they can germinate." On the contrary, this dormancy is overcome by changes in hormones and the "push power" of the embryo.

I would recommend a few other changes in future editions of the book. While the fruits for some species are shown (e.g., *Persea americana*, *Aesculus hippocastanum*, *Punica granatum*), adding images of the distinctive fruits or structures for the Mickey Mouse plant (*Ochna kirkii*), sausage tree (*Kigelia africana*), and rambutan (*Nephelium lappaceum*) would be appreciated. For clarification, I would identify all of the structures on the bean seed figure (p. 10) similar to the corn seed. Also, I would additionally label the hypocotyl and radicle (or simply embryo) on both the bean and corn seed. The graph on p. 27 needs clarification since no y-axis label is present; does the graph show documented uses among all species or only those that are faced with extinction?

Laying aside these criticisms, did the book accomplish its purpose in providing a snapshot of the incredible diversity of seeds? The answer: a resounding yes! I thoroughly enjoyed going through the book and reminding myself of this great diversity.

–Jeffrey L. Walck, Department of Biology,  
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