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Registration Now Open!

IN THIS ISSUE...

From the Editor

Greetings,

Welcome to 2021! As I write this in early March, my institution has just released the first official sign-up for faculty Covid vaccinations. It is exactly one week shy of a year since campus closed in March 2020. Although campus essentially reopened in July, doing my job is not the same as it was a year ago.

As I peruse this issue of *Plant Science Bulletin*, it strikes me that the articles share a theme. They discuss how botanists of the past and present have used the technology of the time to share botanical knowledge and inspire others. Although botanists have been participating in and perfecting online teaching and learning for decades, it is fair to say that the pandemic has forced many events that might have otherwise been in-person to virtual platforms. As a community, botanists have been able to respond in innovative ways. Just as in the past, botanists have been able to harness the resources available to reach broad audiences.

I hope you enjoy these articles and find them useful. If you have a teaching or outreach experience that was modified due to the pandemic and you would like to share, please reach out to me!

Sincerely,

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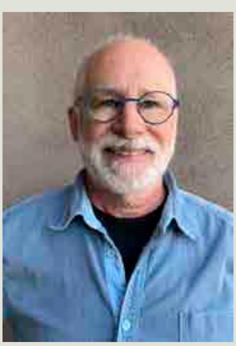

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Botany with Spirit: Cornell Rural School Leaflets and Gardening

> *Nature-study is not science.*
> *It is not knowledge. It is not facts.*
> *It is spirit.*
> *It is concerned with the child's outlook on the world.*
> -L. H. Bailey, 1903

In a recent *Plant Science Bulletin* issue, author Karen Penders St. Clair (2019) introduced us to several early botany instructors at Cornell University. Several of these instructors, namely Liberty H. Bailey, Anna B. Comstock, Alice G. McCloskey, and John W. Spencer, were profoundly important in making Cornell University synonymous with that of early-1900s nature-study education. One of the factors that helped establish Cornell's nature-study program was farm kids and the trouble that they seemed to be in. The economic depression in the early 1880s resulted in chronic low produce prices and increased costs to farmers. As farming communities fought against rising debt, many farms were lost and rural migration to cities soon followed. In New York, this migration proved so worrisome that the state formed a Committee for the Promotion of Agriculture. Anna Comstock was an early committee member who suggested that Cornell's Department of Agriculture develop a nature-study program for rural schools (Doris, 2002). Comstock and others feared that children and teenagers moving to urban areas would soon lose touch with nature, and along with it, an abandonment of their appreciation for the green world.

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In the United States, the idea of studying nature in an outdoor setting did not first appear at Cornell, but in Chicago, essentially at the same time that the United States was struggling with economic depression. Teacher educators such as John Dewey made the University of Chicago a hub for progressive education. One of Dewey's ideas that quickly took hold in the upper Midwest was the idea of hands-on study and using the outdoors for play and exploration. A colleague of Dewey's, Wilbur Jackman, became one of the earliest recognized proponents of nature-study in the early 1890s (Kohlstedt, 2008). Early nature-study texts by Jackman (1891) and botanist John Merle Coulter (1909), also at the University of Chicago and later president of the Botanical Society of America in 1896 and 1915, helped establish nature-study education's roots in Chicago. In addition, the 1894 Report of the Committee of Ten on Secondary School Studies and its subcommittee meeting at the University of Chicago dealing with the topic of natural history education saw its 10 members recommend nature-study for elementary grade school children. Among the subcommittee members were botanist Charles E. Bessey, BSA's second president (1895) John M. Coulter, and nature-study advocate Charles B. Scott from the St. Paul school system in Minnesota. The committee members agreed that the primary goal of nature-study was to interest young children in nature and to gain knowledge by hands-on exploration in the outdoors environment (National Education Association, 1894).

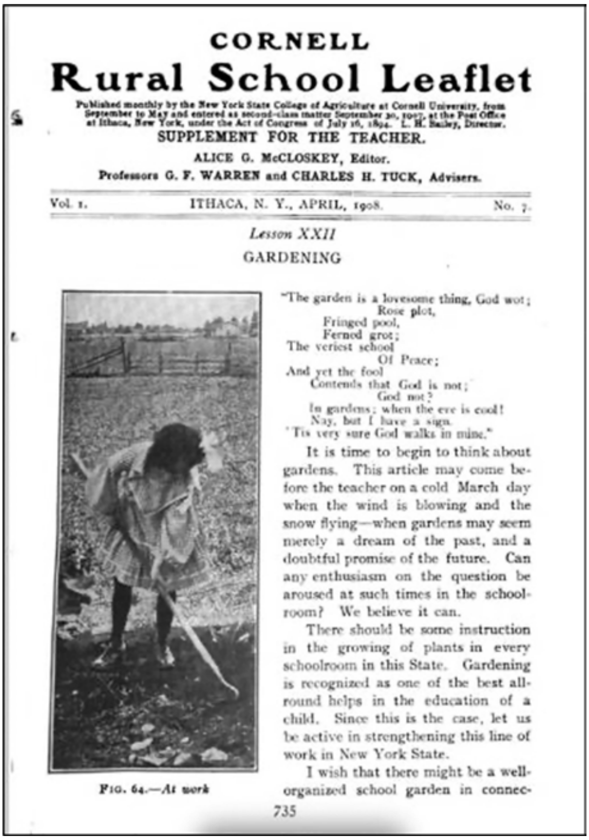
From Chicago, outdoor education spread across the Midwest and eastern states, most notably embraced by two Cornell University faculty members: Bailey, a horticultural science professor who served as the president of BSA in 1926, and Comstock, who in later years was awarded the title of nature study professor. Unlike teacher programs at Chicago and Columbia University, Bailey and Comstock's nature-study program targeted rural, rather than urban, school children. This was mainly due to the fact that Cornell was surrounded by farmland, woods, and water—all available resources for the many rural school teachers and their students in western New York. These two educators, along with others at Cornell, were aided in 1894 and 1903 by the state's decision to give large grants to Cornell to establish an agriculture college, along with funds for the hiring of new faculty, some of whom advocated for the teaching of agriculture and nature-study in rural schools.

Under Bailey's guidance, the agriculture college at Cornell University galvanized nature-study education by gathering naturalists, agriculturists, and educators together to produce a myriad of teacher workshops, student leaflets, teacher's guides, courses for farmers, magazines, handbooks, and naturalist clubs. It is an understatement to say that the nature-study movement at Cornell was anything but prolific.

As a technically trained botanist and friend of Coulter, Bailey distinguished between nature-study and more systematic work in natural history and biology. Nature-study, Bailey argued, would lead not to new truths but, rather, to a sympathetic attitude toward nature. At the turn of the century, nature-study resonated well with the public audience and attracted such supporters as Theodore Roosevelt, University of Iowa botanist Thomas H. McBride, and, later, the nature writer Aldo Leopold (Kohlstedt, 2005).

CORNELL RURAL SCHOOL LEAFLETS

Bailey and Comstock so earnestly believed in nature-study that they expended new energy to launch a nature publication intended for rural school teachers and their students. The *Cornell Rural School Leaflet* (*CRSL*) was published by Cornell's College of Agriculture from 1907 to 1959 (Fig. 1). Financed with a New York state grant, one of the conditions set by the state was that educational leaflets be distributed only to New York state teachers



CORNELL

Rural School Leaflet

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey, Director.

SUPPLEMENT FOR THE TEACHER.

ALICE G. McCLOSKEY, Editor.

Professors G. F. WARREN and CHARLES H. TUCK, Advisers.

Vol. 1. ITHACA, N. Y., APRIL, 1908. No. 7.

Lesson XXII

GARDENING

"The garden is a lovesome thing, God wot;
Rose plot,
Fringed pool,
Ferned grot;
The veriest school
Of Peace;
And yet the fool
Contends that God is not;
God not?
In gardens; when the eve is cool!
Nay, but I have a sign.
'Tis very sure God walks in mine."

It is time to begin to think about gardens. This article may come before the teacher on a cold March day when the wind is blowing and the snow flying—when gardens may seem merely a dream of the past, and a doubtful promise of the future. Can any enthusiasm on the question be aroused at such times in the schoolroom? We believe it can.

There should be some instruction in the growing of plants in every schoolroom in this State. Gardening is recognized as one of the best all-round helps in the education of a child. Since this is the case, let us be active in strengthening this line of work in New York State.

I wish that there might be a well-organized school garden in connec-

FIG. 64.—At work

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Figure 1. The April 1908 Cornell Rural School Leaflet *for teachers with gardening highlighted (p. 735).*

and students, with the hope that children who remained on farms and in small towns would now study and appreciate nature and agriculture in a local setting. Nature-study advocates at Cornell also encouraged children to take what they were learning home to their parents, many of whom had a limited educational background, to develop more receptiveness to scientific practices and a love of the rural environment. Bailey was certain that nature-study could help train future farmers and future farmer housewives to think twice about leaving their idyllic countryside for New York City.

The *CRSL* publications were of two forms: those intended for teachers and shorter leaflets for students. Teacher leaflets were mailed at the beginning of the school year and provided overviews and suggestions of how to use nature-study with students. The teacher was provided with a form to fill out with students' names, which was sent back to Cornell. The student leaflets were mailed, normally three or four times a year, to the school teacher who then distributed them to his or her students.

Areas of study proposed by the *CRSL*s ranged from bee-keeping, raising chickens, milk-testing, and of course, studying plants. In examining a number of early leaflets, I found that botany content lent itself to one of four categories: gardens and their connection to county, state, and Cornell agriculture fairs; plants in their own habitats and their ecological importance; forestry and lumber; and problems for plants (fungal diseases and weeds). The focus of this article is on *CRSL*s and school gardens.

While leaflets and pamphlets may have made the idea of nature-study inviting, most rural teachers taught in a one-room schoolhouse with different-age students (Fig. 2). These same teachers had a limited science background and trying out something new with such a wide variety of ages outdoors probably made class control worrisome to many instructors. Even teachers who took a basic science course in progressive normal schools were not taught the pedagogical skills to teach nature-study (Kohlstedt, 2005). To allay fears, the editors of *CRSL* published many testimonials from successful nature-study teachers. Some teachers expressed their initial hesitation with nature-study, but they provided anecdotal evidence of how they themselves, along with their students,

Figure 2. One-room schoolhouse in West Edmeston, Madison County, NY. This is the type of school setting that the Cornell Rural School Leaflet *targeted (date unknown, personal collection).*

benefitted educationally and spiritually from nature-study and, in particular, gardening. In addition, teachers were encouraged to attend Cornell's summer teacher institutes where they would learn how to implement nature-study in their classrooms.

CORNELL RURAL SCHOOL LEAFLET AND GARDENING

The term "nature-study" often conjures up ideas of walking through the woods, looking for birds, insects, trees, leaves, and flowers. A large number of the early *CRSL*s, however, were devoted to gardening. In the first *CRSL* issue, sent to rural school teachers in September 1907, Bailey exalted that gardens were for everyone. Gardens involved students of all ages and were used as an incentive to reward hard work, establish school spirit, and recognize the economic value of plants—so that when students had their own farms, they would use sound scientific practices to plant and harvest their crops.

Bailey identified four types of school gardens for teachers' consideration. First, the ornamental garden to make the school grounds attractive to the community and to develop civic-mindedness in students. Second, the plot-garden in which students would obtain hands-on experience with edible-food gardening. Here, the plants chosen to grow in the garden bridged the gap between wild nature and domesticated learning (Fig. 3). The third garden identified by Bailey was the problem garden, a scaled-down version of an experimental field garden, in which experiments could take place. The problem garden did not have to stand alone, but could just be a cordoned-off area in the plot garden (Bailey, 1907). Last, there was the wild garden,

Figure 3. *Ithaca school plot garden.* Cornell Rural School Leaflet *April 1908, p. 736.*

an area already growing plants where children would transplant wild and local plants in it. Bailey instructed teachers to start slowly and to choose just one garden to work on first. It did not matter which type, since any school garden was considered a laboratory of living things.

Alice McCloskey, editor of the early nature-study leaflets, also placed special emphasis on school gardens in the first *CRSL* issues. She claimed that the garden and garden activities formed one of the most important features of work in nature-study agriculture. McCloskey was adamant that nature-study was not merely an opportunity for rural students, but that nature-study was an absolute right of every rural child to "know the possibilities that lie in intelligent work on the farm" (McCloskey, 1907, p. 5).

Like Bailey, McCloskey urged teachers to start small and simple. The benefits would far outweigh the initial risks since gardens offered "inquiry, accuracy, patience, perseverance, and courage in time of adversity" (McCloskey, 1908, p. 754). While other nature-study ideas like dairy cows were also discussed in many issues of the *CRSLs*, the school garden and the Corn Day competition at Cornell were heavily revisited and placed in every teacher's edition from 1907 through 1910.

Making a successful garden is not easy. The *CRSL* provided the groundwork for teachers with instructions on how to situate and design a garden and offered activities that students could do in their school gardens (Gowans, 1908). These activities, some of which teachers could modify into experiments, included determining the composition of soil, investigating the capillarity of soil, growing alfalfa under variable conditions, how deep to

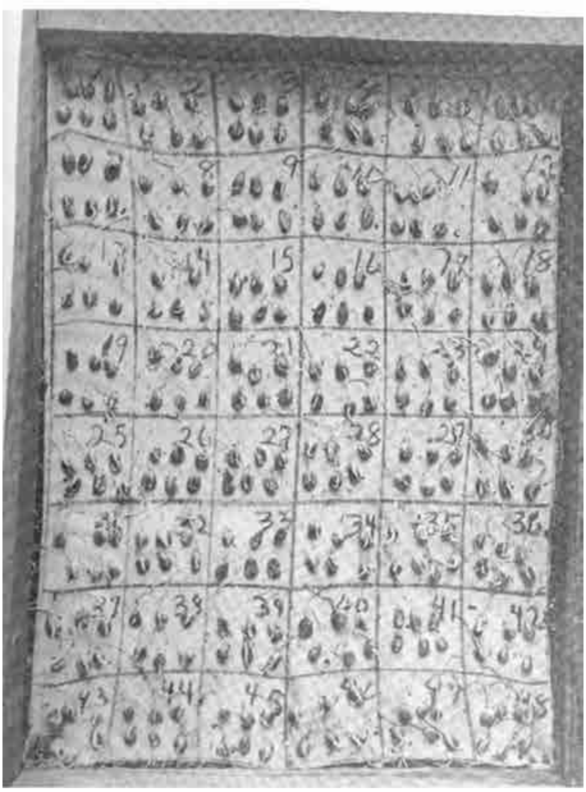

Figure 4. *A germination box comparing different corn seeds in preparation for gardening work. From* Cornell Rural School Leaflet *February 1909, p. 143.*

plant beans seeds, treating potato tubers with formaldehyde to prevent scab, and placing seeds in different experimental conditions (Fig. 4).

Gardens also provided an incentive to students in the form of awards, by entering the best of their crops in local or state fairs. Without fail, Corn Days, Aster Days, and Flower Days were promoted by the *CRSL* editors and students were urged to send their best entries to Farm Days at Cornell. Many of the agriculture competitions required that students grow crops or flowers and develop displays outside of the classroom. It was felt that such work helped students assume responsibility and develop a duty to their teachers, peers, and parents. Added to this was the experience that students gained by following the life cycle of a plant and seeing it through to the competition. This experience was holistic because the plants were grown outside in a field or a garden where the environment—the impacts of the soil, rainfall, and sunny days—were directly involved with the life cycle of the plant.

In 1910, the state education board's newly released nature-study syllabus was published in the *CRSL*. The previous looseness of nature-study, with its emphasis on the study of all things local and seasonal, now gave way to a specified list of special plants for study, trees for study, flowers for study, animals to study, insects to study, birds to study, and so on. Rural teachers soon found that they had less control over what was taught and much more content to cover. For example, the first leaflet for teachers in 1907 was only 12 pages long. The September 1911 *CRSL* for teachers was an astounding 172 pages long. And none of those pages included much talk about school gardens or local learning. There were a few short articles about vegetable gardens as rumblings of war in Europe emerged, but for the most part, it would take the country's entry into World War I to make gardens important again with nature-study.

SCHOOL GARDENS, CORNELL RURAL SCHOOL LEAFLET, AND WWI

As U.S. involvement in the war in Europe intensified, so too did the concern about food shortages at home. In 1917, the Bureau of Education created the United States School Garden Army. Funded by the War Department, these gardens became known as victory gardens or war gardens. The School Garden Army targeted school children to grow food produce. President Woodrow Wilson was a strong advocate of school gardens, linking children's garden work to military patriotism. Eventually, the National War Garden Commission was founded and took steps to "militarize" the students. Urged to help, students were given an insignia and a rank, along with instructions about food production. Not everyone, though, agreed with the Commission's approach. Critics like former Harvard president Charles Eliot believed that hyping children up with patriotic duty was wrong. He urged Wilson and the Commission to stop referring to school children as soldiers—they were simply children planting seeds (Kohlstedt, 2008).

How did the Agriculture College at Cornell react to outside agencies now involved with student gardens? The *CRSL* September 1917 issue for teachers saw its editor, Edward Tuttle, noting that the increase in gardens in the U.S. was due to the demand for food production. This new garden movement presented, in Tuttle's words, "opportunities and many dangers" (Tuttle, 1917, p. 282). Tuttle stressed that children's gardens should serve as an educational opportunity with an education department oversight, rather than a federal commission. To Tuttle, the various agencies now involved with gardens was worrisome since they could easily manipulate children to place more importance on production quotas and therefore be viewed as a worker more than an inquisitive child. As the government became more involved with gardening, the pedagogy of nature-study gardens disappeared into the background.

In the same issue, a reprint of a 1908 article by Alice McCloskey, founder and late editor of the *CRSL*, was published under the title, "Gardening with Children." Her question of what gardens provided students with, whether the country was at war or peace, included civic pride, landscape design, planting and harvesting, and generosity with giving the crop to neighbors and friends.

Gardens were again targeted as a prime way to make school grounds attractive with an article written by Cornell's landscape architecture professor Ralph W. Curtis (1917). A sketch of how to properly place shrubs and a wildflower garden for a good school ground appearance

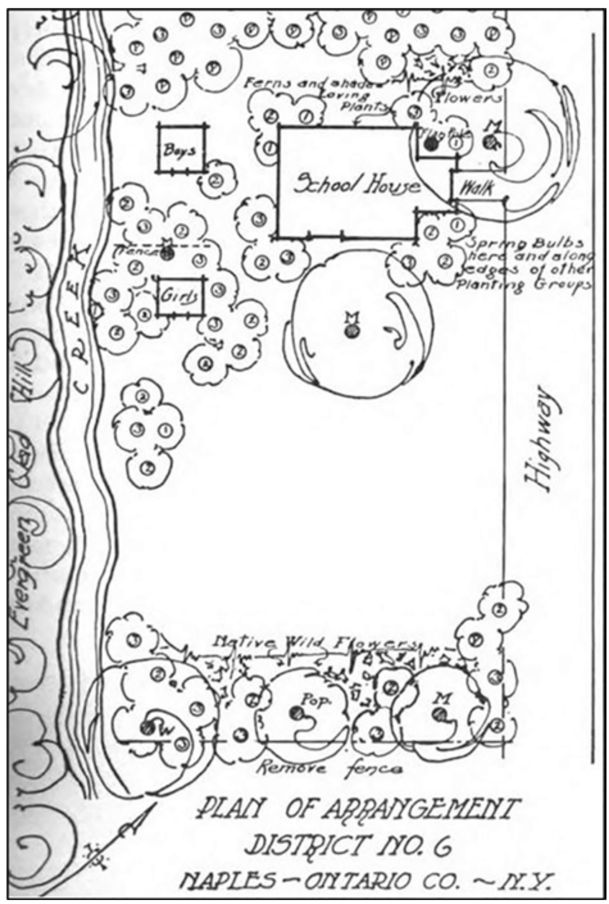

Figure 5. Landscaping school grounds; another use of gardens in Cornell Rural School Leaflet *November 1917, p. 299*

was provided (Fig. 5). The use of McCloskey and Curtis's articles made the appeal to teachers that gardens were multipurpose and not solely intended as food munitions for war.

In the November 1917 issue of *CRSL*, teachers were offered information on something new: junior home projects. Although previous *CRSL*s contained information about home gardens and raising cattle and poultry on farms, the introduction of the junior home project reflected on the ongoing war in Europe and production of food for home and abroad. The *CRSL* again stressed the need to place all student agricultural and domestic science activities under the jurisdiction of the State Department of Education, lest "selfish exploitation of boys and girls" should continue (Griffin, 1917, p. 326).

Students interested in home projects, including tending to gardens, were now required to fill out paperwork for the school superintendent, who would communicate with the student and his or her teacher, who would communicate with Cornell's College of Agriculture staff, who would then provide preliminary instructions to the student and teacher. The College also sent record books for the student to keep track of costs and income in order for academic credit. The flow chart shown in Figure 6 illustrates the top-down approach to gardening during the war. All of this regimentation certainly would have irritated Bailey. Although Bailey retired as Dean of the Agriculture College in 1913, he continued to promote the idea that farmers and children of farmers needed a nature-study outlook, instead of just money to guide them (Bailey, 1908).

The decline of school and home gardening after World War I is noted by contemporary historians Sally G. Kohlstedt and Kevin C. Armitage. In particular, Kohlstedt (2008) attributes the decline of gardens to a lack of government support and a diminished national attention to patriotic school kids. This was most likely true for victory gardens, but what about nature-study's attachment to school gardens? Did rural school gardens also disappear? An examination of *CRSL*s published before and after World War I does show a reduction in the number of garden articles, but this decline actually started before the war. There are several reasons for this decline in gardens with nature-study.

By the early 1900s, biologists were moving from field laboratories to the more-controlled science laboratory located inside of a building. This move was accompanied by the belief that science education should also make such a migration and take on a more rigorous approach to the teaching of science. For example, an article published recently in *Plant Science Bulletin* introduced us to botany educator and former BSA president, William Ganong (Sundberg, 2020). In Ganong's book *The Teaching Botanist* (1915), he faulted nature-study instruction since it deprived the science-minded student the opportunity to find his or her chief interests. What Ganong may have meant here is that students were not exposed thoroughly enough to astronomy, chemistry, physics, or other fields of science at an early age. Ganong also criticized student drawings of plants that he considered too impressionistic and not scientifically correct.

The sentimentality that teachers expressed for nature was also criticized. Many university biologists believed that good science meant objectivity, not sympathy toward plants and animals or reciting poems about them. As the practice of science and science education veered toward quantification of results, critics posed the question of how you could quantify

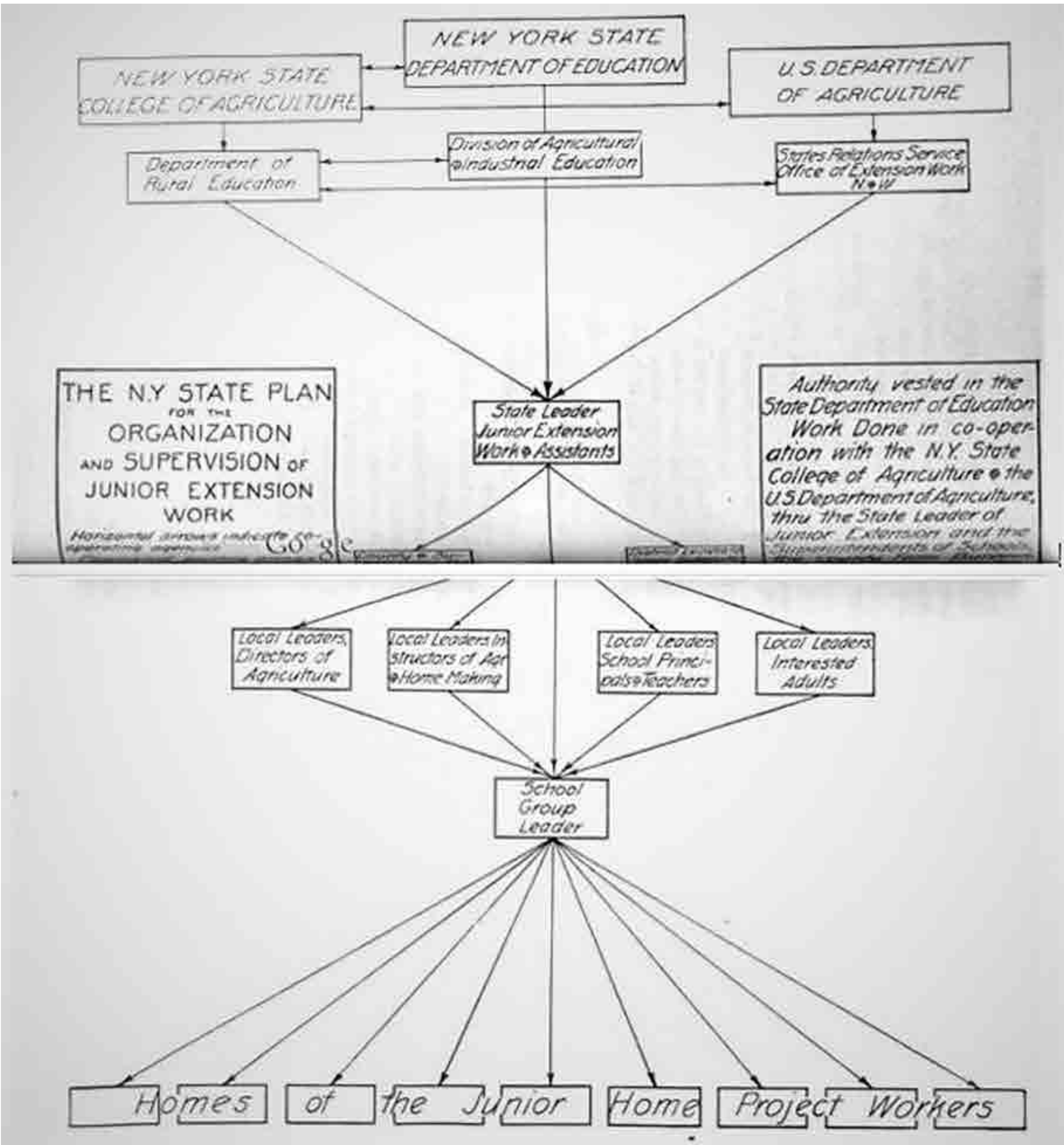

Figure 6. Planting gardens during WWI becomes driven by patriotism rather than inquiry. From Cornell Rural School Leaflet *November 1917, pp. 348-349.*

something as vague as appreciation and respect. Other scientists were vocal about the pedagogical rigor of nature-study and its lack of experimental design (Armitage, 2009).

Other biologists and educators did not criticize nature-study itself, but faulted the teachers involved with it. It should be noted that a majority of rural teachers were women while their critics were men in higher education or science occupations. Teachers were attacked for having no understanding of nature or the scientific method. Such teacher incompetence, scientists and science educators argued, led to an unscientific study of one's surroundings and an emotional view of nature. Buoyed with poems and sing-songs, nature-study seemed to lack the scientific and disciplinary character called for by scientists starting in the early 1900s (Beal, 1902).

Around 1914, rural education changed its focus as state legislators called for a more robust and vocationally focused agriculture curriculum in rural schools (Kleibard, 2004). Nature-study critics argued that these problems could be resolved by giving students a solid, scientific agriculture education rather than a romanticized study of nature that included frolicking about in gardens. This change in the nature-study curriculum was followed by the 1925 Cole-Rice Law, which provided building aid for the construction of large centralized schools. The one-room schoolhouse quickly became a thing of the past, along with established connections that nature-study advocates at Cornell had fostered with rural school teachers. Teachers were no longer encouraged to make decisions about science study based on the local environment. Outdoor field trips, collecting leaves, and tilling the school garden were replaced by textbooks and classroom demonstrations.

By the mid-1930s the term "nature-study" was replaced the term "elementary school science" (Palmer, 1957; Tolley, 1994). In the September 1932 edition of *CRSL* for teachers, the editor wrote that the State Education Department was ready to publish its tentative science outline for elementary schools. This was accompanied by content objectives for each area of study, broken down for grades 1-2, 3-4, and 5-6. In education, content objectives often pave the way for standardized testing, which means that teachers must meet the objectives, often at the expense of doing anything else. The very nature of unit tests was at odds with Bailey's reasons for nature-study. In Bailey's words, state departments wrongly viewed examinations to be the only test of student learning. Nature-study was intended to be so informal that it could not possibly lend itself to systematic examinations (Bailey, 1899).

Nonetheless, the *CRSL* continued throughout the 1930s, although its focus was now on conservation education. While forests, animals, and soil were still a part of nature-study, the emphasis was now on the "jobs" that those things did for humans rather than the development of student sympathy and inquiry surrounding the outdoors. Cornell's nature-study program and field botany began serious unraveling in the 1940s, as the call for more efficiency and more content in schools pushed nature-study out the door. In the September 1940 *CRSL*, editor Palmer made a plea to teachers to take their students outdoors. He stated that science teaching was now confined to a classroom and a textbook, making teachers hesitant to go outside. He offered background materials with teacher directions for field trips that could even take place during recess time (Palmer et al., 1940). Some of Palmer's suggestions included visiting electrical powerlines and junkyards, which seemed in sad contrast to forests and gardens. In 1958 the *CRSL* changed its name to the *Cornell Science Leaflet*. It was now available to all students, rural or urban, for 20 cents a copy. The new Cornell publication made it only to March, 1959 with a short leaflet dedicated to birds. The impact of the *CRSL*, however, did not end in 1959. The leaflet spurred the publication of other like-minded teacher publications by biological supply companies and was a model for *The Kansas School Naturalist* (1954–present) (M. Sundberg, personal communication, January 19, 2021).

SUMMARY

Nature-study was devised to counter a loss of rural life and the connection to the natural world. Initially, Cornell's nature-study program was a combination of agriculture and less-altered habitats for study. Plants such as corn and beans were studied alongside wild orchids and skunk cabbage. With such a broad program (remember that zoology, entomology, meteorology, agriculture, and botany were all part of nature-study), the Progressive Era naturalists at Cornell sought to prepare students (and teachers) to observe, think, predict, and plan. As school districts became centralized and science in general became more experimental, the science curriculum underwent a top-down, content-laden approach that teachers were required to closely follow.

While critics lamented about nature-study's lack of inquiry, I found that the early *CRSL* writers provided many garden and plant questions for the teacher to ask of students. Some of the questions had the potential to lead to what we now call guided inquiry and project-based learning. Rather than memorize a myriad of plant parts, students were to study the plant as a whole. For example, Bailey (1903) provided the types of questions that teachers could ask in the field when coming upon dandelions: where does it grow? Do dandelions on the lawn look like dandelions along a roadside? As students worked more and more with whole plants, Bailey suggested looking at plant societies: what plants grow together and where? In this way, students were involved with categorizing on their own, rather than reading about plant categories from a text. Students were encouraged to keep field notebooks and gardening journals while in school and during the long summer vacation. Of course, songs and poems were always part of the *CRSL*s and this is what naysayers focused on. If critics had critically read the *CRSL*s, coupled with the understanding that children learn and process information differently than adults, they most likely would have approved many experiential aspects of nature-study, including the spirit of outdoor gardening.

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Teaching a Distance Botany Laboratory with Online, Outdoor, and Hands-On Exercises

Abstract

Even before the global pandemic accelerated the trend toward online learning, the number of online and remote STEM courses, including those with laboratories, had been steadily increasing. Including botany courses with laboratories as part of these offerings increases student exposure to this discipline. However, it is a challenge to create engaging remote laboratories that foster interest and allow students to interact directly with plants. We describe our approach to teaching a non-traditional botany laboratory that combines a laboratory kit with plants with outdoor and online activities. We describe the communication strategies and laboratory exercises, with links provided for activities and kit provisions. Additionally, we highlight lessons and continuing challenges in order to help other instructors create related courses.

Key words

Biology laboratory, distance education, laboratory kits, online laboratory, remote learning

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Online enrollments across disciplines have steadily increased (Seamen et al., 2018), with more than 30% of college students at public and non-profit institutions in the United States enrolled in at least some distance education courses in 2018 (U.S. Department of Education, National Center for Education Statistics Fast Facts, 2019). The shift to online learning due to the pandemic may lead more students and instructors to adopt and retain distance education approaches.

Online and face-to-face (F2F) courses differ in the students they attract. Most notably, non-traditional students are more likely than traditional students to enroll in online courses, especially in STEM courses (Pontes et al., 2010; Wladis et al., 2015a,b). Female students are generally more likely than male students to enroll in online courses (Shea and Bidjerano, 2014; Wladis et al., 2015a; U.S. Department of Education National Center for Education Statistics Table 311.22, 2018), especially in STEM disciplines (Wladis et al., 2015b). In contrast, Black and Latino students are less likely to enroll in online STEM courses (Shea and Bidjerano, 2014; Wladis et al., 2015a), particularly after accounting for gender and non-traditional characteristics (Wladis et al., 2015b). Finally, students are more likely to enroll in online courses if they live farther from campus (Shea and Bidjerano, 2014) or have physical disabilities (Pontes et al., 2010; Faulconer and Gruss, 2018). These demographic differences suggest that a mix of online and traditional botany courses would reach a broader group of students.

For STEM courses, including botany, it is challenging to deliver laboratory content that meets learning objectives without F2F instruction. Laboratory learning objectives may go beyond reinforcing content knowledge from lecture and include (1) the ability to engage in aspects of the scientific method and communicating scientific results; (2) developing career-readiness competencies, including problem-solving, teamwork, communication skills, and proficiency with digital technology; and (3) practical discipline-specific skills (Faulconer and Gruss, 2018). While it has been suggested that F2F labs are central to scientific education, reviews of studies have found that students achieve learning objectives similarly in both F2F and non-traditional laboratories for STEM courses generally (Brinson, 2015) and biology courses more specifically (Biel and Brame, 2015). It has also been suggested that online labs are effective lower-cost alternatives to F2F laboratories (Chirikov et al., 2020), although a mix of both approaches can be even more effective (Sypsas and Kalles, 2018).

Asynchronous formats better accommodate students with scheduling conflicts due to work, family, or limited computer access (Harris et al., 2020), although Brinson (2015) recommends using a mix of synchronous and asynchronous approaches for laboratories. Non-traditional laboratories may be taught exclusively online or involve hands-on activities. For labs delivered electronically, Faulconer and Gruss (2018) distinguish between "online labs," which typically rely on simulations or archived materials and "remote laboratories," in which students manipulate instrumentation via computer. These researchers suggest that hands-on labs in which students physically interact with supplies that students gather, retrieve from campus, or receive through a shipment be termed "distance laboratories," with the category "non-traditional laboratories" comprising remote and distance formats.

Non-traditional laboratories can help to achieve the discipline's long-standing goal of strengthening education and communication about plants and the economic and environmental services they provide (Botanical Society of America, 1995) by reaching more students and a different subset of students. Botanical education must overcome "plant awareness disparity" (Parsely, 2020), a non-ableist term that describes the condition wherein people lack awareness, recognition, and appreciation of plants and their roles in ecosystems and societies (Wandersee and Schussler, 1999). We think that letting students interact with living plants is the best way to foster an interest in plants, so we prefer a distance-laboratory format when feasible. Moreover, an advantage of distance laboratories generally is that students are able to directly interact with materials to have opportunities for tangible results and sensory feedback (Faulconer and Gruss, 2018). However, the ability of students to acquire and maintain plants away from campus is limited by their disparate geographic locations, climate, and living arrangements. Additionally, acquiring supplies has costs, whether to the student or the institution. Outdoor exercises are also limited by geographic, logistic, and safety considerations. Online laboratories based on freely available datasets and activities create flexibility without adding expense.

To address tradeoffs between distance and online laboratories, we have adopted a hybrid approach that mixes online and distance laboratory approaches.

BOTANY & SOCIETY LABORATORY

We describe here the required laboratory for a course titled "Botany & Society," an asynchronous, 4-credit, general-education course for non-science majors taught at a southeastern regional comprehensive university. The lecture portion of the course follows a typical asynchronous online format, with narrated lectures available on YouTube, associated readings, quizzes associated with each lecture, supplemental learning activities, and multiple exams. Laboratory exercises, which support the learning objectives listed in Box 1, reinforce lecture content while emphasizing botanical skills, critical thinking, hypothesis testing, the scientific method, and digital communication skills.

Box 1

Learning objectives for Botany & Society, a general-education, asynchronous botany laboratory for non-science majors.

- Gain experience growing and manipulating plants
- Recognize features that distinguish different plant groups
- Understand role of observations and the scientific method to learn about natural world
- Be able to use databases and online tools to investigate the natural world
- Increase proficiency in communicating science in writing and using technology

The laboratory, taught over either a 14-week semester or 8-week summer semester, includes 16 exercises with a mix of online, outdoor, indoor plant, and lab-kit based activities. Most exercises are completed in a single assignment, while others extend across multiple weeks. Exercises are described below with additional details and instructions for students provided at tinyurl.com/onlinebotany. Assessment is based on completion of assignments and comprehension questions instead of lab practicals.

Many exercises require live plants, safety equipment, and other supplies, which are provided in a laboratory kit assembled by the instructors and either picked up by students or shipped to them (Figure 1). The only supplies students procure themselves are isopropyl alcohol, a flower for dissection, and produce for a macromolecules exercise. Each kit contains a unique set of stickers, which students affix to items they photograph to ensure that the photographs they submit are of their own work. An $80 laboratory fee covers the cost of supplies and shipping.

Table 1. Laboratory exercises divided into activity type (outdoor, online, growing plants, etc.), as well as the associated assessment method(s). Most assignments, except those submitted to Padlet, are completed using tools on Blackboard, the course learning management system or are submitted there.

Laboratory Exercise	**Assessment Method(s)**	**Laboratory Exercise**	**Assessment Method(s)**
Growing and manipulating plants:		**Primarily outdoor activities:**	
Terrariums with Spore-bearing Plants	Padlet	Leaf Morphology	Quiz, Word-doc
Fern Development	Journal entries, Padlet	Tree ID using Key and iNaturalist	Pre-lab quiz, Word-doc
Coleus Cuttings & Grafts	Pre-lab quiz, Padlet	Community Plant/ Citizen Science Activity (also online)	Video post to Padlet, Journal entry
Floral Parts	Padlet		
Primarily online activities:		**Lab kit exercises:**	
Tree Rings/ Dendrochronology	Quiz	Twig ID	Quiz
Gymnosperm ID	Quiz, Journal entry	Starch Test	Quizzes, Padlet
Nutrition Sources	Journal entry	DNA Extraction	Pre-lab quiz, assignment, Padlet
Phenology	Pre-lab quiz, Padlet, Quiz	Radish Genetics	Pre-lab quiz, Padlet, Online spreadsheet entries, Quiz
Cooling Power of Trees	Word-doc		

Figure 1. *Photograph of contents of laboratory kits distributed to all students at start of semester.*

COMMUNICATION TECHNOLOGIES

Students perform better in non-traditional courses when they are deeply engaged and experience frequent high-quality interactions with peers and instructors (Jaggers et al., 2013; Biel and Brame, 2016; Jaggers and Xu, 2016). In asynchronous laboratories, prompt feedback helps students to successfully complete exercises when they encounter obstacles (Faulconer and Gruss, 2018). We use a variety of tools to facilitate students' submission of assignments and their interactions with peers and instructors (Table 2).

To give students flexibility in communication options, we provide three contact methods: email as well as phone, and text through Google Voice, thus increasing overall rates of communication. Courses, including laboratories, may be enriched by using a broad array of information and communication technologies (Dede and Grimson, 2013; Sit and Brudzinski, 2017). While this approach requires spending more time teaching and troubleshooting technology, it has two advantages: (1) it allows flexibility to find and adapt teaching resources appropriate to the course learning outcomes, and (2) it allows development of technological skills, a career-readiness competency. Assignments and links to other programs are organized through the Blackboard learning management system (LMS).

We think that students benefit from seeing one another's work, as they would in a F2F laboratory. This approach has two benefits: (1) students can self-assess and make corrections if their results deviate from classmates' results, and (2) viewing other's work helps to create community among students, which increases student success (Harris et al., 2020). Submissions for most assignments include photographs or screenshots documenting the students' work. Padlet is our preferred program for allowing students to share their results, including text images and videos, with instructors and classmates; each student's work is in a separate column (Figure 2). To provide guidance, the instructor models a successful submission in the first column. Because students can see classmates' work, Padlet is only appropriate when the goal is for students to document completion of a process (e.g., dissection of a flower; Figure 3), or when students have unique results from analyzing different data sets (e.g., phenology curves, each for a different species).

When students need to respond to questions without the benefit of reading classmates' responses, we require submissions directly through the LMS. We use tests when automated grading for adaptive release is needed, such as for pre-lab questions whose completion triggers release of subsequent instructions. We use journals for submission of text-heavy

Table 2. *Communication technologies employed and their primary use.*

Technologies Employed	Primary Use
Blackboard (Bb) Learning Management System	Deliver course content including announcements; administer assessments, including quizzes, journals, and assignments for students to upload documents
Padlet	Students post photos, videos, and text to share with class. $8-per-month plan provides sufficient functionality (limited free version also available).
Flipgrid	Students post videos to share with class, thus building community. Free plan.
Excel Online	Students share and analyze data.
Email; Text and Phone (Google Voice)	Individual communications

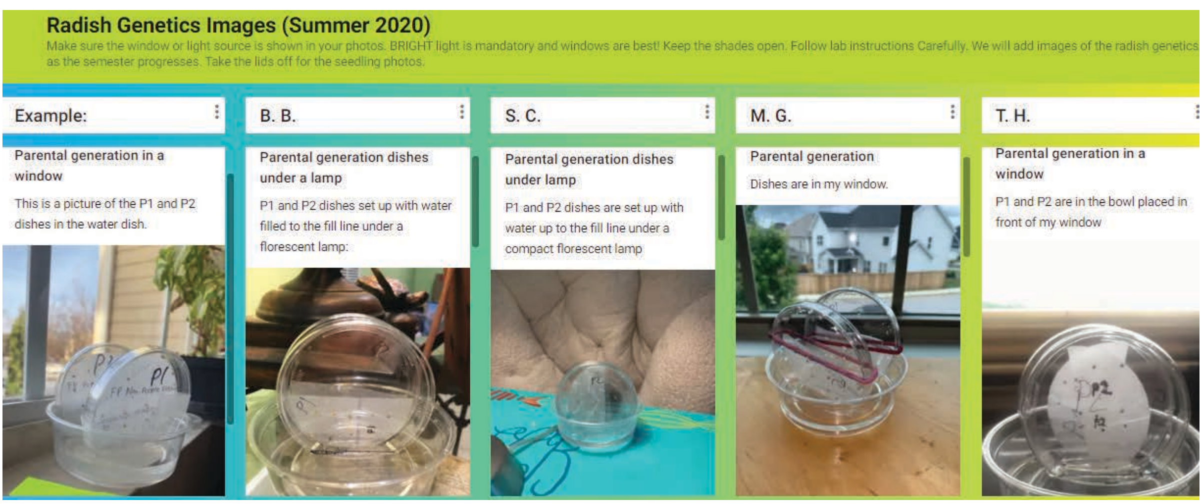

Figure 2. *Example of Padlet online bulletin board tool used for student submissions of text, images, and videos that are shared with classmates.*

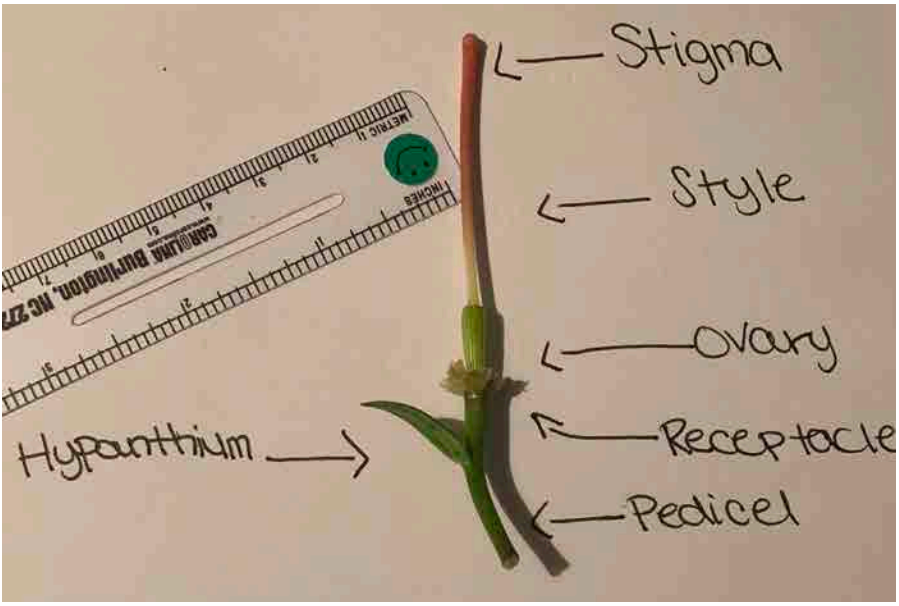

Figure 3. *Example of flower dissection performed by student.*

updates on multiweek exercises. In other cases, we have asked students to embed images into word-processing documents for submission, but recent LMS updates that have simplified uploading images make submissions into journals more practical. We use other technology less frequently, including FlipGrid for ice-breaker video introductions to help create a sense of class community and Excel online for students to share data.

LABORATORY EXERCISES

Assignments may be divided into those that involve growing plants, interacting with plants outdoors, lab-kit-based activities, and online activities (Table 1). We include three activities where students cultivate plants over an extended period: (1) bryophyte and lycophyte terraria, (2) fern spores for lifecycle observations, and (3) *Coleus* plants used to make cuttings and a graft. For the *Coleus* exercises, students are given two plants with different leaf colors. They are responsible for watering and providing adequate sunlight or artificial light to maintain the plants. For the grafting exercise, adapted from Readel (2000), students graft a scion from one plant onto the other, creating a multi-colored *Coleus* (Figure 4). For the cutting exercise, students place the leftover stem from the grafting exercise in a cup of water to observe adventitious root growth. In the fern lifecycle activity, students are provided a Petri dish pre-inoculated with spores, and they observe growth of gametophytes and sporophytes, with supplemental images and videos also provided. Students ultimately transplant ferns into soil. For the terrarium project, students assemble replicate terrariums in disposable plastic bowls with inverted-bowl lids. Students transplant a moss, liverwort, and spikemoss into each and put them into two light environments. The paired terraria allow comparison of how light levels affect growth and provide redundancy (Figure 5).

Figure 4. *Example of* Coleus *grafting.*

Figure 5. *Photographs of terrariums grown by students at start of semester (top) and end of semester (bottom).*

Outdoor exercises emphasize identification or keying skills. The Leaf Morphology Laboratory gives students hands-on experience with botanical terminology necessary for subsequent laboratories. Students find and photograph a specified number of examples of leaf complexities, basic leaf shapes, margins, tips, and bases from outdoor plants they select. Students add their photos to an LMS journal and specify the relevant trait. Teaching use of dichotomous keys is a challenge without immediate feedback to keep students on track. We avoid this problem by embedding couplets into the test feature of the LMS, each specimen with its own test and questions introduced sequentially. Each question starts with the correct answer to the previous couplet and then asks students to choose between the next two couplet choices. This way, students always proceed to the correct couplet. We introduce dichotomous keys with a simple gymnosperm key and images of several easily keyed specimen. We also require students to find one gymnosperm, preferably a pine, in a natural area to photograph and identify. Students submit photographs, their list couplet choices, and their identification.

In a subsequent exercise, students use a dichotomous key to identify native trees. They also learn how to use the iNaturalist app for tree identification and compare the accuracy of these two methods. Students choose a natural area in which to photograph and key out dicot trees using a dichotomous key provided. Submissions include photos of each tree identified and all choices they made from the dichotomous key to arrive at their identification. Students also upload photos of the trees they have identified to iNaturalist for identification. Finally, they check their identifications against images on a flora website. During the spring semester, when it is impractical to use leaves to key deciduous trees, we substitute a keying exercise using winter twigs, with twigs from several species included in the supply kit and keying based on Stucky (2003).

Students investigate Mendelian genetics by studying inheritance of hypocotyl anthocyanin production in radish using kits acquired from Carolina Biological Supply Company. Each student is allotted four half seed discs, each of which contains seeds from one parental variety, or the F1 or F2 generations. Over consecutive weeks, students germinate each generation, photograph seedlings, score phenotypes, and record results on a shared Excel spreadsheet. Students make Punnett squares to analyze patterns of inheritance.

Students practice hypothesis testing and reinforce knowledge of macromolecules in two exercises. First, they make a hypothesis related to the amount of DNA in diploid rice germ and hexaploid wheat germ, and they test their hypothesis by extracting DNA from both and qualitatively comparing outcomes. Second, students make hypotheses and predictions about the amount of starch in onions versus potatoes and underripe versus ripe bananas. They test these hypotheses qualitatively by performing the iodine test for starch.

Three online activities investigate relationships between climate and plants. The Tree Rings/Dendrochronology Laboratory reinforces knowledge about how climate affects the thickness of tree rings. Additionally, a pine tree slice (cross section) is provided for students to determine its age at harvest. Students also visit the UCAR Center for Science Education website (https://scied.ucar.edu) to read about dendrochronology and play interactive games that demonstrate how moisture, temperature, and the interaction of these factors affect the size of tree rings.

Another activity uses the Data Visualization Tool provided by the USA National Phenology Network (usanpn.org/usa-national-phenology-network) for students to create phenology curves, with each student investigating a different species. Students then test hypotheses about the relationship between leaf emergence and two variables: temperature and latitude. Finally, students predict how climate change will affect the timing of spring phenological events. In a third exercise, the Cooling Benefits of Trees, students investigate effects of trees on their home environment, carbon sequestration, and other ecosystem services. Students identify trees around their residence, measure their girth, and estimate the trees' environmental and financial benefits using i-Tree Design (https://design.itreetools.org/) by using a map they construct on the program's interface. Also, they consider how adding another tree could increase energy savings.

Finally, students also assess the role of plants in their diet by keeping a food journal for one day and using the USDA website (www.myplate.gov) to calculate how much fruit, vegetables, grains, protein, and dairy they consumed. The website also generates a personalized dietary plan (MyPlate Plan) for their daily requirements for each food category. Students then compare their actual diet to the recommendations and typically find they are not eating enough plant foods.

A Community Plant Activity was recently designed for students to volunteer at a local garden, park, or nature center on a plant-based project and to reflect about the experience in a journal. An alternative online citizen-science option was to contribute to one of the plant biology projects at Zooinverse (www.zooinverse.org) by digitizing handwritten botanical specimens. Considering the pandemic, this became the only option. Students reflected on this experience afterwards in a video journal. Students reported that they found the experience of contributing to the scientific knowledge base especially rewarding while self-quarantining.

LESSONS AND CHALLENGES

Lessons we have learned while teaching this course include the following:

1. It is important to explicitly teach students technological skills and provide an orientation at the outset (Biel and Brame, 2016; Garman, 2012). Most Week 1 activities are practice exercises taking photographs of plants and uploading them to Padlet and journals in the LMS.

2. Lab kits should not be distributed until after add–drop to avoid loss.

3. Shipping kits with live plants adds expense and logistical challenges, so requiring students near campus to pick up supplies saves effort. Additionally, instructors should have a plan for how to accommodate students from foreign countries or regions where live plants cannot be shipped due to phytosanitary restrictions—or if accommodations cannot be made, how to prevent students from these locations from enrolling.

4. Our lab activities are low risk, but safety training should be included in the first week and subsequent exercises when relevant. Successful completion of a poison-ivy–identification quiz is required to adaptively release instructions for the first outdoor exercise.

5. Some outdoor exercises call for students to visit natural areas. This requirement could feel more challenging and pose greater risks for some students. In practice we do not penalize students who select planted specimen, and students have not yet raised this issue with instructors or on course evaluations.

6. To keep students on track with the asynchronous modality, it is important during complex exercises that instructors create opportunities for students to assess their understanding (Biel and Brame, 2016) and self-correct. Strategies can include computer-graded quizzes; adaptive release of parts of assignments with each part beginning with a summary of the previous part; or multiweek assignments, with the

instructor providing feedback in the interim.

7. It is important to create a welcoming atmosphere and include synchronous and asynchronous communication options with fast response times. Proactive communication to non-participatory students is beneficial.

8. Instructors should create an inclusive learning environment by accommodating disabilities, the schedules of non-traditional students, and disparities in access to technology, technological proficiency, and internet access (Harris et al., 2020).

There are geographic and class-size limitations to the course structure described here. Geographic limitations arise in part from shipping challenges and because identification keys are geographically limited. Consequently, it is helpful if most students enrolled live within the region. The class-size limitation arises because the asynchronous structure leads to more time devoted to one-on-one communication with students than in a face-to-face laboratory. This time commitment may be reduced by providing clear instructions, thereby reducing need to answer questions, with use of teaching assistants, or by developing peer-guidance mechanisms.

Although this online botany lab was developed for non-majors with student success in mind, the course is rigorous. Students get a variety of hands-on plant experiences designed to introduce them to botany, the scientific method, and the beneficial roles of plants in our lives and on Earth. By providing the lab kit, good communication practices, and interesting, well-planned activities, students are primed for engagement and success.

Acknowledgments

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FROM THE *PSB* ARCHIVES

60 years ago:

Ralph E. Cleland discusses how to encourage graduate work in Botany:
"Second, I would advise them that the best way to prepare at the undergraduate level for graduate work in science is to obtain as broad an education as possible. I would urge them to gain a rich background in the humanities and social sciences, to emphasize especially the arts of writing and speaking, and to acquire a good grounding in foreign language (preferably in two languages). Overemphasis on science at the undergraduate level leads to the development of high grade mechanics. We need scholars, not mere technicians, in the field of science. Given comparable abilities, the graduate student in botany who has a broad education is much to be preferred to the person who has overspecialized in his chosen field as an undergraduate at the expense of a liberal education."

Cleland, Ralph E. 1961. "Supply and Demand in Relation to the Ph.D." *PSB* 7(1): 1-2

50 years ago

William L. Stern further discusses graduate training, citing the Cleland 1961 paper.
"In reviewing some of the recent literature resulting from attempts to improve the training of botany graduate students to teach, and while examining early issues of *Plant Science Bulletin* (e.g., Miller, 1955; Cleland, 1961), on the one hand I was struck by the inventiveness and imagination of college teachers in devising complicated methods to train graduate students to teach, and on the other hand by the absence, or near absence, of suggestions about who, specifically, will carry out these various training methods.

. . .

However meritorious the several plans for teaching teaching assistants to teach, none will work well unless the teacher-trainer is recognized and rewarded for his efforts, rather than penalized for them, as seems to be the case in so many institutions of higher learning. This fact must be brought forcefully to the attention of university administrators. Acceptance of this reality must progress hand-in-hand, or even better, it must precede efforts to improve the training of graduate teaching assistants in the pedagogical process."

Stern, William L. 1971. "Responsibilities of Universities to Provide Trained Botanists for Undergraduate Education" *PSB* 17(1): 2-3.

40 years ago

"Shoals Marine Laboratory; Appledore Island, Isles of Shoals, Maine is offering two courses that might be of interest to readers: Adaptation in Marine Organisms and Field Phycology. Shoals Marine Laboratory is a cooperative filed station of Cornell University and The University of New Hampshire."

--Summer Courses *PSB* 27(2): 16.

When a Titan Arum Blooms During Quarantine (aka, Making a Stink Online)

This past May and June, 2020, during the early COVID-19 quarantines, at the height of the virus outbreak in New York City, our collection's *Amorphophallus titanum* (aka, Titan Arum, Corpse Plant) decided it was going to send up its first bloom (Figures 1–4). The following is a brief recounting of that event, along with a few observations and lessons learned along the way.

OF ALL THE TIMES

In 2006, The Brooklyn Botanic Garden's (BBG's) *A. titanum* specimen "Baby" sent up the first recorded bloom in NYC in nearly 70 years. It was an event met with great public celebration and media coverage throughout the city, and it brought widespread fascination with the plant into public consciousness. A number of years after the event, the garden decided to develop a new crop of *titanums*. Ours came from that crop, as an inter-conservatory gift of goodwill. Upon arrival at our greenhouse, it was a humble, young, 3-inch corm weighing about a pound. For the last eight years we've been cultivating it, with great affection, patience, and aspirations. Only a lucky few ever get to see these plants bloom in the native wilds of central Sumatra; the rest of us botanists and plant lovers must bring about a bloom *ex situ* if we're ever to bear witness to its singular presence. For an institutional greenhouse, blooming events such as these are prime opportunities to engage a wide public audience and bring attention to a host of relevant issues. We hoped that we could hold our own festive on-site event to inspire others, as the BBG event had inspired us. We were looking forward to the opportunity to enthrall both our campus and the local community in the wonder of the Titan's bloom.

As most readers here likely already know, the blooming of *A. titanum* in a conservatory setting is no longer the uncommon event it once was. Today, it is not as momentous an occasion as when Kew Gardens bloomed the first in cultivation in 1889, or when The New York Botanical Garden bloomed their first in 1937. As seed availability and horticultural knowledge have proliferated, mature specimens and their inflorescences have

By Nick Gershberg
Greenhouse Manager
The Arthur Ross Greenhouse at Barnard College, New York, NY

Sited on the roof of one of the original academic halls at Barnard College, The Arthur Ross Greenhouse is a plant conservatory of 2,000 ft² under glass, with dedicated space for faculty research and student projects.

Figure 1. *'Berani' (Indonesian for "Bold"), approximately 10 to 12 years old, blooming for the first time, May/June 2020.*

Figure 3. *From the ground up.*

Figure 2. *Detail within the spathe.*

Figure 4. *Overhead view.*

become staples in conservatory. Nonetheless, it is still a superlative event in the botanical world, and the blooming at Barnard is still an important and long-anticipated event for our community.

Any team that has successfully brought an *A. titanum* to bloom, or achieved a similarly rare botanical event, understands this sentiment. Beyond the sheer excitement of the occasion, a corpse plant blooming is evidence that a greenhouse is doing a solid job of providing care 365 days of the year. Beyond being a point of pride (clearly), it also comes with a certain sense of relief, which may feel familiar to growers reading along. On the long road to a bloom, any number of things can happen (e.g., one cold night, a few days of too much or too little moisture, a random hapless accident) and years of cultivation can be voided before one has even realized it has happened. So for many of us, being able to enjoy the tangible product of a capable team of horticulturists is a welcome occasion.

Each time one of these plants blooms, it's an opportunity for a greenhouse to put its best foot forward and make the most of the outreach potential of these "megaflora" events. At the very center of any conservatory's mission lies the message of stewardship. While the plant effortlessly does the work of drawing public interest (among the beetles and flies), the story of its lengthy cultivation inherently reinforces the notion that stewardship takes more than just good intentions and wholesome aspirations. It demands hard work, dedication, knowledge, and patience.

But nature is on its own timeline. Despite our best intended interventions as growers, it more often than not shows little concern for our ends. And, famously, these titans tend to keep a particularly unpredictable schedule. It was only on the final day of our quarantine preparation, just before the "stay at home" orders were issued in New York State, that our plant began to emerge from a long dormancy period. As much as we'd hoped for a bloom for so many years, we would have been content with just another majestic leaf this time around. So, weeks later, when there was no doubt that our plant had begun to bloom in the midst of the nationwide quarantine, it was frustrating and a bit of a disappointment. There was no way we could safely receive visitors at our facility. Not even our student worker staff, who had been instrumental in plant's the daily cultivation, was allowed on campus at that stage.

As it happens, all was not lost. It turns out folks are quite fond of the internet. And despite the setback, we were intent on sharing the bloom with as much of our community and beyond as we possibly could. First, in a matter of a few days, we prepared a livestream of the plant, which was posted on YouTube (Figure 5). Often just a supplement to the in-person experience, a live stream feed for this bloom would be our community's primary window into the greenhouse. Initially, I was surprised at how much technical knowhow was involved in setting up the various elements of the stream. But, largely thanks to the help of an impromptu, remote collaboration of our college's IT and digital media staff, we were soon able to broadcast 24/7. In addition, using the greenhouse's existing Instagram account (@barnardgreenhouse), we staged a public naming contest (as is the custom), updated and informed our audience with regular posts, and used "Instagram Live" as an impromptu platform for interacting directly with the public. Finally, a few days after the inflorescence waned, we created a beautiful time-lapse of the 48 hours of opening and closing, which has proven a

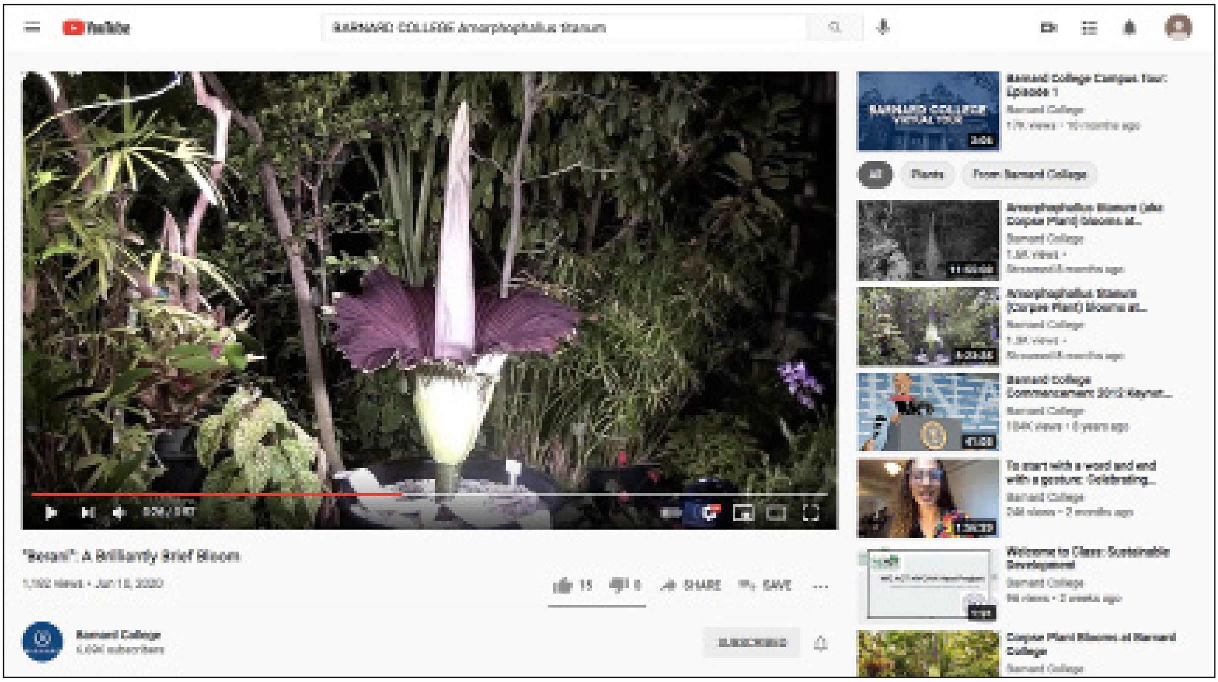


Figure 5. *Screenshot from YouTube.*

cherished memento. In retrospect, thanks to the staggering connectivity of the internet, it's possible that we reached a much larger, more diverse audience than if we only had an on-site event. Without a doubt, it was an object lesson in the potential that digital and social media offer for science and education outreach.

MAKING THE BEST, OF THE BEST

As a conservatory, fostering science literacy and educational outreach is a large part of our mission. When visitors come to the greenhouse, it is our job to elicit the "spark" of interest in the plants we house and to create the momentum that will generate further interest and desire for more knowledge. We try our best to provide our guests with clear, factual, thoughtfully contextualized, and relevant information. Greenhouse curators routinely rely on an array of charismatic plants to facilitate conversations with visitors. It's important to remember that we're speaking to audiences with a diversity of interest. Some of our guests are of course already very interested in plants and are connoisseurs in their own right. Others are less so, and some are not initially interested at all. When young children come to the greenhouse, after an initial introduction, we usually begin by asking whether they like ice cream. Even if they're not particularly interested in the plants, they are definitely interested in chocolate and vanilla! So we show them our vanilla orchid vine, and our cacao trees. When burgeoning scientists come, we point out the fascinating potential for biotechnology that plants such as cacao possess, and discuss how our particular plants were grown from tissue culture for potential commercial use. And if it eats insects, moves rapidly—or both—it is sure to engage a crowd.

It's long been known that the use of charismatic flora and fauna is a highly effective tool in science outreach, and it provides great opportunities to cleverly introduce more sophistication into the scientific vernacular. For example, a key point we emphasized from the start of our coverage is that what people were witnessing was not *the world's largest flower*, but instead *the world's largest unbranched inflorescence*, or single structure containing many dozens or hundreds of individual flowers. Throughout the two to three weeks of the ongoing event, we were able to introduce many more concepts, of greater nuance and sophistication, from topics including tropical biogeography, systematics and taxonomy, ethnobotany, morphology, pollination and reproductive ecology, and conservation biology. We were also able to bring attention to the history of often exploitive colonialist aspects of "discovering" any tropical plant taxa, and to affirm the importance of local guides and indigenous knowledge, both historical and current.

Over the years, we've come to appreciate that there are myriad cultural connections with almost all of our taxa, making them interesting subjects for classes in sociology, history, literature, etc. In that sense, we've promoted the greenhouse collection as a resource for most, if not all of the other departments at the college, on some level. Figure 6 shows an example of one of the interdisciplinary connections we made during the corpse plant blooming.

IMPROVISE, ADAPT, OVERCOME

In this digital age online media is now the mainstream, and certainly the norm among our student body. The Titan Arum blooming event affirmed that as educators, we need to embrace this online trend. Moreover, that means not just using the preferred platforms of our student audience, but also adapting to the pace they set. That's not necessarily an easy proposition, as education and advocacy have to keep up and maintain relevancy in the midst of nearly constant stimulation. We must continually strive to provide high-quality content, in an eloquent manner, often in a way that is interdisciplinary and cross cultural. Given the urgency to start an engaged awareness of the natural world early, it is our goal to reach as wide an audience as possible. By establishing these connections using modern platforms, we can fulfill this job of raising awareness, encouraging scholarship, fostering a committed sense of stewardship, and promoting informed action. Hopefully, if we can connect on common ground with broad appeal, we will help create a truly open and robust entry point for the STEM pipeline, available to the widest possible range of individuals.

There were some hurdles to clear in creating our online event. The main lesson we learned is that it's of vital importance to have a working familiarity with the setup and gear involved, and to practice to gain proficiency. To my surprise, no one person or department on our campus was familiar with the soup-to-nuts process of setting up a live stream for public viewing. I had to enlist the help of about a dozen individuals, across several departments, to make it work—and under

Figure 6. *Interdisciplinary connections: "Who wore it best?"*

quite unusual circumstances since almost nobody was actually on campus. It may have seemed like a fairly basic operation, given the ubiquity of live streaming lately, but in actual fact, it was seldom needed, so the process took some effort to bring to bear. It's advisable to build these skills and interdepartmental relationships early, so that all of the components are effectively ready to go.

Fortunately, the fact that we had already cultivated a social media follower base meant that, when we had exciting, ephemeral content, there was someone to share it with. While we did of course use the college's existing traditional media outlets, they were somewhat static by comparison and lacked the innately interactive quality of social media. Just as with the live stream hardware setup, though, online platforms take time to develop well. As a relative social media novice myself, learning to craft content that's at the standard of our in-person visitor experience, and that has a comparable "voice," has taken time. A big thanks goes to a number of our greenhouse student worker staff, who put time in over the course of the last few years to help cultivate an engaging and worthwhile platform. Creating more immersive informational hubs like websites can be extremely time-consuming as well and are subject to a host of technical issues. Our own site has been a long work in progress and is a high priority as the management and purposeful utilization of data continues to pave new paths in science. So it makes sense to view not only developing content, but also the means to disseminate it, as an ongoing process.

In the last year, this concept of a hybrid model for outreach and institutional engagement has, by sheer necessity, taken a huge leap forward. If anything, though, the process has just been accelerated by circumstance, as there has long been a need to close the gap between "real world" and online scholarly resources.

In cultivating on-site and online content synergistically, ideally, each one serves as a follow-up resource for the other. Whether you're a small institutional greenhouse with a modest collection like ours at Barnard College, or a large, world-class institution, there exists great potential to enhance the user experienceand provide access to more diverse audiences, with nearly instant pathways for cultivating meaningful content.

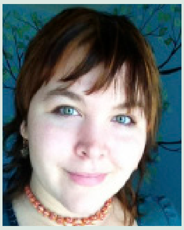
LOOKING BACK

I'd like to take a moment to acknowledge that, in addition to happening during the quarantine lockdowns, this bloom event converged with a time of unprecedented social upheaval. The nation, and the entire Barnard community, were outraged and heartbroken over the murder of George Floyd, Jr. and were activated in the ubiquitous decrying of systemic violence against Black Americans. As the protests and national dialogue emerged as the events of true importance at that moment, how we proceeded was intently focused on not overshadowing them. Furthermore, our own community was already in a state of coping with the recent devastating death of a student. So we must remember that whenever these celebrated events occur, they occur necessarily in the human context of everything else going on at the time. We hope, at the very least, that our event was uplifting in some small way, in the face of these truly serious, important, and deeply personal matters.

Now that our plant has returned to dormancy, we hope that the traditionally mounted pressing of the full inflorescence we have successfully made will be a tangible memento that students can marvel at in person upon their return. But we look forward to pursuing our outreach role online as well, as best we can, with all the latest tools at our disposal. Looking back at 2020, a year of highs and lows, I'm ever more grateful our plant provided us an opportunity to focus on something positive, that brought our community together for a short while in mutual admiration. If the study of plants teaches us anything, it is that nature persists and finds ways to adapt even in the most unlikely of environments. Hopefully we can continue to reflect this lesson, into 2021 and beyond.

Spring 2021 PlantingScience Session Summary

With the addition of a new, pandemic-friendly module—the Tree-Mendous Benefits of Trees (https://plantingscience.org/benefitsoftrees)—and the continued popularity of the Wonder of Seeds module, we have a large spring session with 28 groups! The participating schools range from in-person to hybrid to remote learning schedules, and we are thrilled and grateful to these teachers for bringing their students to the platform. We are also seeing new mentors signing up and quickly being assigned to teams. Students and mentors were busy introducing themselves and coming up with research projects.



By Dr. Catrina Adams, *Education Director*
Dr. Jodi Creasap Gee, *Education Technology Manager*

MENTORS URGENTLY NEEDED FOR NEW TREE-MENDOUS BENEFITS OF TREES MODULE

Seven of the 28 PlantingScience groups are using the new module, thus creating an urgent rush in demand for mentors who are willing to mentor for this module. The 32 mentors who have updated their profiles are swamped! If you or someone you know might like to mentor middle- and high-school students as they work through this fun module, please update your profile at https://plantingscience.org/login or register to be a mentor on PlantingScience at https://plantingscience.org/register now!

TEACHING REMOTELY WITH PLANTINGSCIENCE

Between the fall and spring sessions, we surveyed PlantingScience teachers and developed a new resource: Remote Learning Tips (https://plantingscience.org/psteachers/remotelearningtips). This resource can help teachers determine which module might work best and how to make it work in their classes, be they remote, hybrid, or in-person. We hope it provides useful guidance for all of our teachers.

Student team names have been especially creative for the PlantingScience Spring 2021 Session. Can you pick a favorite?

THE 7TH LIFE DISCOVERY CONFERENCE

The 7th Life Discovery: Doing Science Conference will be held next October in Estes Park, CO, from Sept 30-Oct 2, 2021 (public health conditions permitting). The theme is "Pushing Past Barriers: Ecological Science for All." We are still seeking education share fair proposals if you are interested in presenting ideas in development. We would love to have a larger BSA presence at the conference. This small (approximately 150 attendees) conference includes many opportunities to discuss important topics in biology education and network with others passionate about teaching. Check out the conference website for more information: http://www.esa.org/ldc.

Please join us at the 7th Life Discovery: Doing Science Biology Education Conference

NEW PLANTS ARE COOL TOO! EPISODE NOW AVAILABLE

Check out the latest episode of Plants are Cool, Too!, and please help amplify the reach of this botany outreach resource by sharing with your colleagues and students: https://www.youtube.com/watch?v=Y1zNfODhM4o.

"Highlighting one of the coolest and most ambitious projects in the history of rare species conservation, this episode ("Team Schiedea") takes us to Kaua'i, Hawai'i, where a group of passionate plant people are working to save some of the rarest plants on the archipelago—and tell us why we need a new generation of biodiversity lovers to help battle the extinction crisis."

Roundup of Student Opportunities

It's that time of the semester where you start to compile every opportunity you want to apply to into one list. To make this easier for you, we have compiled a list of all the opportunities we know about. Even if the deadline of this application cycle has passed for this academic year, make sure to check by the end of this year for the next application cycle. Below, we have divided these into categories for easy browsing that include the following: BSA Grants and Awards, Fellowship, Research Awards, Broader Impacts, Short Courses and Workshops, Job Hunting, and ways that may help you to travel to Botany 2021. At the end of the student section, we included recommended reading for future leaders.

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

By Shelly Gaynor and Imeña Valdes
BSA Student Representatives

BSA GRANTS AND AWARDS

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

Donald R. Kaplan Award in Comparative Morphology		
Amount: $10,000	**Deadline:** March 15th	**Purpose:** Research Funds
More info: https://cms.botany.org/home/awards/awards-for-students/kaplancomparativemorhpology.html		

BSA Graduate Student Research Awards & the J. S. Karling Award		
Amount: $1,500	**Deadline:** March 15th	**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.-March	**Purpose:** Research Funds
More info: https://cms.botany.org/home/awards/awards-for-students/		

BSA Undergraduate Student Research Awards		
Amount: $200	**Deadline:** Mid.-March	**Purpose:** Research Funds
More info: https://cms.botany.org/home/awards/awards-for-students/		

BSA Young Botanist Award		
Amount: NA	**Deadline:** Mid-March	**Purpose:** Recognition
More info: https://cms.botany.org/home/awards/awards-for-students/bsayoungbotanistawards.html		

FELLOWSHIPS

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

American Association of University Women (AAUW) Dissertation Fellowship	
Amount: $20,000	**Deadline:** Nov. 1st
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/	

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

Research Fellowships/Awards from the Arnold Arboretum	
Amount: Up to $10,000	**Deadline:** Feb. 1st
Nationality/Affiliation requirement: Fellowships differ in requirements.	
Purpose: Multiple awards and/or fellowships are offered for undergraduate and graduate students with topics that focus on Asian tropical forest biology and comparative biology of woody plants.	
More info: www.arboretum.harvard.edu/research/fellowships/	

Banting Postdoctoral Fellowships	
Amount: $70,000 per year	**Deadline:** Unknown for 2021
Nationality/Affiliation requirement: Open to Canadian citizens and permanent residents of Canada.	
Purpose: To promote research in Canada and Canadian scholars abroad.	
More info: https://banting.fellowships-bourses.gc.ca/en/home-accueil.html	

Burroughs Wellcome Fund: Career Awards at the Scientific Interface	
Amount: $500,000 over five years	**Deadline:** Jan. 8th
Nationality/Affiliation requirement: Open to U.S. and Canadian citizens, permanent residents, and temporary residents.	
Purpose: To bridge advanced postdoctoral training and the first three years of faculty service. Research bridging computational and biological approaches; PhD typically in chem, physics, math, etc.	
More info: https://www.bwfund.org/grant-programs/interfaces-science/career-awards-scientific-interface	

CIC Smithsonian Institution Fellowship	
Amount: $40,000 for one year	**Deadline:** Unknown for 2021
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: $27,000 - $50,000 for 1-3 years	**Deadline:** Dec. 2021
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	

Fulbright U.S. Student Program	
Amount: Variable	**Deadline:** Spring 2021
Nationality/Affiliation requirement: Must be citizens or nationals of the U.S. at the time of application; permanent residents are not eligible.	
Purpose: Covers transportation and living expenses in the host country. Tuition and school-related fees covered in some countries.	
More info: http://us.fulbrightonline.org/about/types-of-awards/study-research	

National Science Foundation Graduate Research Fellowship Program (NSF GRFP)	
Amount: $34,000 per year + tuition aid	**Deadline:** October.
Nationality/Affiliation requirement: Must be a U.S. citizen, national, or permanent resident.	
Purpose: Support outstanding graduate students in NSF-supported disciplines who are pursuing research-based Master's and doctoral degrees at accredited U.S. institutions.	
More info: https://www.nsfgrfp.org/	

National Science Foundation: Earth Sciences Postdoctoral Fellowships	
Amount: Varies	**Deadline:** September 8th.
Nationality/Affiliation requirement: Must be a U.S. citizen, national, or permanent resident.	
Purpose: Earth science research including geobiology and paleobiology; current theme: "issues relating to scale".	
More info: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503144&org=NSF	

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

Schlumberger Foundation Faculty for the Future Fellowship	
Amount: Up to $50,000 per year	**Deadline:** Unknown for 2021
Nationality/Affiliation requirement: Applicant has to be a woman from developing/emerging economies.	
Purpose: The program's long-term goal is to generate conditions that result in more women pursuing scientific careers by lowering the barriers women face when entering STEM disciplines, thus reducing the gender gap. Faculty for the Future Fellows are expected to return to their home countries after completion of their studies to contribute to economic, social, and technological advancement by strengthening the STEM teaching and research faculties of their home institutions.	
More info: https://www.facultyforthefuture.net/content/about-faculty-future-program	

RESEARCH AWARDS

In addition to those we list here, check out local societies (e.g., Florida Native Plant Society, Southern Appalachian Plant Society, Washington Native Plant Society Grant, Montana Native Plant Society Grant, Nevada Native Plant Society Margaret Williams Research Grant, Colorado Native Plant Society John W. Marr Research Grant, Arctic Institute of NA Grants-in-Aid Program, etc.).

American Society of Plant Taxonomists Graduate Student Grants	
Amount: Up to $1,500	**Deadline:** March 1st
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: To fund Masters and doctoral students to conduct fieldwork, herbarium studies, and/or laboratory research in any area of plant systematics.	
More info: https://www.aspt.net/awards#.X_yT-5NKhsY	

Awards from New England Botanical Club	
Amount: Up to $3,000	**Deadline:** February 1st
Nationality/Affiliation requirement: None.	
Purpose: To encourage botanical research in the New England region.	
More info: http://www.rhodora.org/awards/graduate.html	

Company of Biologists: Travelling Fellowships	
Amount: Up to £2,500	**Deadline:** March, May, Aug., Oct., of each year
Nationality/Affiliation requirement: Award cannot be paid to those in areas that have sanctions, embargoes, or other political trade restrictions put in place by the United Nations, the EU, or the UK.	
Purpose: Lab visits to work with collaborators; research theme must be covered by Company of Biologists journals.	
More info: https://www.biologists.com/travelling-fellowships/	

Evolutionary, Ecological, or Conservation Genomics (EECG) Research Award	
Amount: Up to $6,000	**Deadline:** Unknown for 2021
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: Priority for funding will be given to proposals that address genome-scale questions, or ecological, evolutionary, and conservation genetics questions that are best addressed using genomic approaches in a hypothesis-testing framework.	
More info: https://www.theaga.org/eecg-awards.php	

Garden Club of America Scholarship	
Amount: $1,000 - $8,000	**Deadline:** Dec. 1st, 31st; Jan. 15th, 31st; Feb. 1st, 2nd, 5th; Jul. 1st
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; projects of a more general or educational nature will also be considered, provided that they include a strong systematics component. Offers a total of 28 merit-based scholarships and fellowships in 12 areas related to conservation, ecology, horticulture, and pollinator research.	
More info: www.gcamerica.org/scholarships	

Grants from the Wetland Foundation	
Amount: Up to $1,600	**Deadline:** Dec. 18th
Nationality/Affiliation requirement: Any student currently enrolled full-time at an academic institution in the U.S.	
Purpose: To support wetland education and research.	
More info: http://thewetlandfoundation.org/grants/	

Herb Society of America Research Grant	
Amount: $5,000	**Deadline:** Mar. 31st
Nationality/Affiliation requirement: Only U.S. residents may apply.	
Purpose: This grant is for the research of the horticultural, scientific, and/or social use of herbs throughout history.	
More info: https://www.herbsociety.org/explore/grants-scholarships/grant-details.html	

International Association for Plant Taxonomy Research Grant	
Amount: Up to $2,000	**Deadline:** Feb. 28th
Nationality/Affiliation requirement: None.	
Purpose: To fund students and young investigators preferably for travel to institutions, laboratory investigations, or fieldwork.	
More info: https://www.iaptglobal.org/grants	

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

National Geographic Young Explorers Grants	
Amount: Up to $5,000	**Deadline:** Unknown for 2021
Nationality/Affiliation requirement: None.	
Purpose: Support research, conservation, and exploration-related projects consistent with National Geographic's existing grant programs. In addition, this program provides increased funding opportunities for fieldwork in 18 Northeast and Southeast Asian countries.	
More info: https://www.nationalgeographic.org/grants/grant-opportunities/	

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

Richard Evans Schultes Research Award	
Amount: Up to $2,500	**Deadline:** Mar. 30th
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: To help defray the costs of fieldwork 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 $1,000	**Deadline:** Mar. 15th; Oct. 1st
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	

Society for Herbarium Curators Student Research Awards	
Amount: $500 or $250	**Deadline:** Feb. 1st
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: To provide funds for graduate or undergraduate students conducting research related to herbarium resources.	
More info: http://www.herbariumcurators.org/awards	

Society for Integrative and Comparative Biology Grant-in-Aid of Research (GAIR)	
Amount: Up to $1,000	**Deadline:** Fall 2021
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: For graduate students in support of their research in the fields of integrative and comparative biology.	
More info: https://sicb.burkclients.com/grants/giarinfo.php	

Society for Integrative and Comparative Biology Fellowship of Graduate Student Travel (FGST)	
Amount: Up to $2,000	**Deadline:** Fall 2021
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: For graduate students for travel and other expenses at distant research laboratories, museums, or field sites.	
More info: https://sicb.burkclients.com/grants/fgstinfo.php	

Society for the Study of Evolution Grants	
Amount: $2,500 - $3,500	**Deadline:** Varies
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: This society has a range of grants that service students pursuing evolutionary research.	
More info: http://www.evolutionsociety.org/content/society-awards-and-prizes/graduate-research-excellence-grants.html	

Society of Systematic Biologist Graduate Student Research Award	
Amount: $1,000 - $3,000	**Deadline:** Fall 2021
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: To assist graduate students conducting research in systematics.	
More info: https://www.systbio.org/graduate-student-research-awards.html	

The Councils of the Linnaean Society and the Systematics Association: Systematics Research Fund	
Amount: £500 - £1,500	**Deadline:** Feb. 15th
Nationality/Affiliation requirement: None.	
Purpose: To encourage research focused on systematics; 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/	

The Exploration Fund Grant	
Amount: $500 - $5,000	**Deadline:** Unknown for 2021
Nationality/Affiliation requirement: Grant does not support proposals for work being conducted in China or by Chinese citizens	
Purpose: To encourage research focused on systematics; projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.	
More info: https://explorers.org/expeditions/funding/expedition_grants	

The Mohamed Bin Zayed Species Conservation Fund	
Amount: Up to $25,000	**Deadline:** Oct. 31st and Feb. 28th
Nationality/Affiliation requirement: Temporary shift due to COVID-19 to not include applications from international NGOs, government-related entities, universities, and other academic institutions.	
Purpose: To support conservationists based in all parts of the world dealing with plant and animal species.	
More info: https://www.speciesconservation.org/grants/	

Torrey Botanical Society Student Fellowship Award	
Amount: $2,500	**Deadline:** Jan. 15th
Nationality/Affiliation requirement: Must be a member of the society.	
Purpose: The Torrey Botanical Society supports student research in botanical research.	
More info: https://www.torreybotanical.org/grants-awards/torrey-botanical-society-grad-student-research-fellowship/	

BROADER IMPACT OPPORTUNITIES

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

PlantingScience	
What is it:	A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
What you can do:	A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
More info:	www.plantingscience.org/

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

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

SHORT COURSES AND WORKSHOPS

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

- Summer Short Course at the Arnold Arboretum (https://www.arboretum.harvard.edu/education/summer-short-course/)
- Tropical Plant Systematics (https://tropicalstudies.org/course/tropical-plant-systematic/)
- Frontiers and Techniques in Plant Science (https://meetings.cshl.edu/courses.aspx?course=C-PLAN&year=20)
- Annual Workshops hosted by evomics.org (http://evomics.org/workshops/)
- Annual Workshop in Evolutionary Biology in Guarda (http://www.evolution.unibas.ch/teaching/guarda/index.htm)
- The Bee Course (https://www.thebeecourse.org/)
- Tropical Field Biology (https://araceae.wixsite.com/tropical-botany?fbclid=IwAR0_Tb29smQG8rTK0wLB-89vekRkO70N6qZZZuLFEw4BpeRWK66RED51ChrU)

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

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

Internship Opportunities

Interning is important to gain experience, to help you figure out what type of research or field you want a career in, and to 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 for the summer, with many of the deadlines in December or early next year. Many botanical gardens, arboretums, and museums offer internship opportunities during the summer, or even throughout the year, so make sure to check the job opportunities of their websites. Here we have a few examples of sites that you can search for internships:

- Botanical Society of America: jobs.botany.org
- Research experiences for undergraduates (REU): https://www.nsf.gov/crssprgm/reu/reu_search.jsp
- Internships offered by The Future Park Leaders of Emerging Change: https://www.futureparkleaders.org/
- Internships offered by the Organization for Tropical Studies (OTS) research station in Costa Rica: https://tropicalstudies.org/portfolio/internships/
- Internship opportunities at the Smithsonian: https://www.smithsonianofi.com/internship-opportunities/
- Fall internship program offered by the National Tropical Botanical Garden: https://ntbg.org/education/college
- Summer internship offered at the Chicago Botanic Garden (REU): https://pbcinternships.org/
- Internship offered at Montgomery Botanical Center: (https://www.montgomerybotanical.org/research/education/#interns)

Graduate/Post-graduate opportunities

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

- EvolDir: http://life.mcmaster.ca/cgi-bin/my_wrap/brian/evoldir/Jobs/
- Ecolog: https://www.conservationjobboard.com/category/ecology-jobs

Academic Teaching Positions

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

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

Government Positions and Non-Academic Jobs

Searches for government jobs can begin at usajobs.gov and 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, so be sure to keep your profile pages updated and polished!

- Government positions: www.usajobs.gov and www.americajobs.com
- Conservation Job Board: www.conservationjobboard.com/category/botany-jobs

Use your University!

Many academic institutions have offices that focus on helping alumni succeed after graduation. Check with your department or institution for resources on job announcements, workshops focused on personal development (such as CV/resume writing or getting a teaching certificate), and networking opportunities. Since Botany 2019, we started to offer CV/resume-reviewing booths for students to have their CV/resume viewed and commented on by professionals. More information regarding the schedules for Botany 2021 will come out soon, so stay tuned!

GRANTS WILL HELP YOU TRAVEL TO BOTANY 2021

We would love to see you at Botany 2021! If Botany 2021 is in person, we outlined funding opportunities to help you afford attending.

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

SOCIETY TRAVEL AWARDS:

Both BSA and ASPT offer travel grants for Botany 2021. BSA travel grants are due April 10th. ASPT has a travel grant lottery that is normally announced in March.

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! BSA travel awards include: Pteridological Section & American Fern Society Student Travel Awards, TRIARCH "Botanical Images" Student Travel Award, Vernon I. Cheadle Student Travel Awards, Developmental & Structural Section Student Travel Awards, Ecological Section Student Travel Awards, Economic Botany Section Student Travel Award, and the Genetics Section Student Travel Awards. These are all due on April 10th.		

Botany 2021 Travel Grants for Presenters from Developing Nations		
Amount: $1,000	**Deadline:** Mar. 15th	**Purpose:** Travel to the conference
More info: https://cms.botany.org/home/awards/developing-nations-travel-grants.html		

PLANTS Grant	
Amount: Variable	**Deadline:** Mar. 1st
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	
If you have never been to Botany, check out the PLANTS grant through BSA. The goal of this program is to enhance diversity at the Botany Conferences. If you receive this grant, the cost of the conference is fully covered, you get paired with a mentor to help you navigate the conference, and you'll be able to participate in networking and professional development opportunities. Check out more about the PLANTS program at https://cms.botany.org/home/awards/travel-awards-for-students/plants-grants.html. (BSA student rep Imeña received this grant in 2015, so feel free to contact her if you have any questions!)	

BSA Student and PostDoc Travel Award		
Amount: $500	**Deadline:** Apr. 10	**Purpose:** Travel to the conference
More info: https://cms.botany.org/home/awards/travel-awards-for-students/grad_postdoc_travel.html		

EXTERNAL AWARDS

Bio REU Travel Grant (Rocky Mountain Biological Laboratory)	
Amount: Up to $2,000	**Deadline:** At least 1 month prior to the conference
Purpose: To present your REU research at a conference.	
More info: Have you participated in an NSF-REU (National Science Foundation Research Experience for Undergraduate) within the past three years? If so, you can request up to $2,000 to present your REU research at a conference through the Rocky Mountain Biological Laboratory Bio REU travel grant (https://www.rmbl.org/students/bio-reu-travel-grant/). You have to apply at least one month prior to the conference, and the total cost of the conference will be fully reimbursed after the conference. One of the current BSA student reps, Shelly, was funded through this program for presenting her work at Botany 2017, so feel free to contact her if you have any questions.	

PP Systems Travel Grant	
Amount: up to $1,000	**Deadline:** Unknown for 2021
Purpose: To present research using the CIRAS-3 Portable Photosynthesis System at a conference.	
More info: Does your research utilize the CIRAS-3 Portable Photosynthesis System from PP Systems? And are you active on social media ("via your own lab blog, Twitter, etc.")? If so, you could apply for up to $1,000 to attend a conference or workshop through PP Systems (https://ppsystems.com/innovators-travel-award/). BSA student member Rebekka Davis (University of Central Florida) received this grant to attend Botany 2019. See her video here (https://www.youtube.com/watch?v=j2_Uj3pcLyI&feature=youtu.be).	

OTHER OPPORTUNITIES

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

PAPERS TO READ FOR FUTURE LEADERS

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

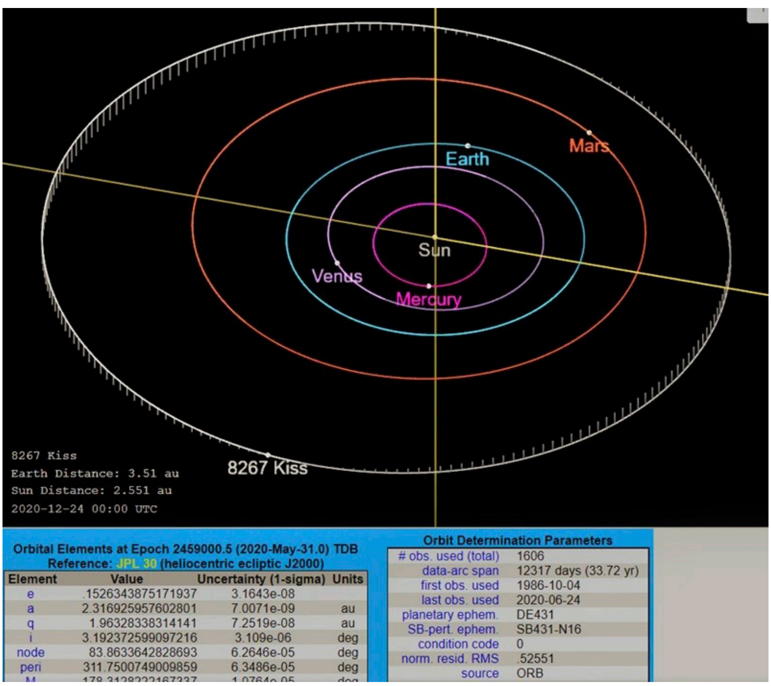
- Baker, K., M. P. Eichhorn, and M. Griffiths. 2019. Decolonizing field ecology. Biotropica 51: 288–292.
- Chaudhary, V. B., and A. A. Berhe. 2020. Ten simple rules for building an antiracist lab. PLOS Computational Biology 16: e1008210.
- Emery, N. C., E. K. Bledsoe, A. O. Hasley, and C. D. Eaton. 2021. Cultivating inclusive instructional and research environments in ecology and evolutionary science. Ecology and Evolution 11: 1480-1491.
- Gewin, V. 2021. How to include Indigenous researchers and their knowledge. Nature 589: 315-317.
- MacKenzie, C. M., S. Kuebbing, R. S. Barak, M. Bletz, J. Dudney, B. M. McGill, M. A. Nocco, T. Young, and R. K. Tonietto. 2019. We do not want to "cure plant blindness" we want to grow plant love. Plants, People, Planet 1: 139-141.
  - "Full disclosure: this is my paper. That said, an inclusive and equitable future in botany includes how we talk about our botanical research—and our love for plants in general—with broader audiences. Stop using ableist metaphors to describe underappreciation, unawareness, and/or ambivalence towards plants!" - Dr. Caitlin McDonough MacKenzie (Colby College)
- Parsley, K. M. 2020. Plant awareness disparity: A case for renaming plant blindness. Plants, People, Planet 2: 598–601.
  - "This is an important issue in Botany education. I feel that if you are a teacher you should understand literature surrounding 'Plant awareness disparity.' As educators, we need to be as politically correct as possible." - Lydia Tressel (University of Texas at Austin)
- Schell, C. J., C. Guy, D. S. Shelton, S. C. Campbell-Staton, B. A. Sealey, D. N. Lee, and N. C. Harris. 2020. Recreating Wakanda by promoting Black excellence in ecology and evolution. Nature Ecology & Evolution 4: 1285-1287.

ANNOUNCEMENTS

AMERICAN SOCIETY FOR GRAVITATIONAL & SPACE RESEARCH NAMES ASTEROID AFTER DR. JOHN KISS

Congratulations to Dr. John Kiss (University of North Carolina, Greensboro), who has been awarded the COSPAR International Cooperation Medal for distinguished contributions to space science and work that has contributed significantly to the promotion of international scientific cooperation; he receives this with Dr. F. Javier Medina of Spain. Along with the medal is the Kiss asteroid (#8267)! Dr. Kiss and Dr. Medina have both been active in international spaceflight research for more than two decades during which they studied the growth and development of plants under microgravity in spaceflight. Both served as principal investigators for a joint spaceflight project named Seedling Growth (SG) where Kiss was funded by NASA and Medina by ESA and the Spanish National Research Agency to conduct studies on board the International Space Station. The Awards ceremony took place during the 43rd COSPAR Scientific Assembly in January 2021 in Australia.

-From a statement by the American Society for Gravitational & Space Research

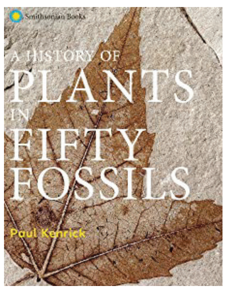


BOOK REVIEWS

A History of Plants in Fifty Fossils
Berries
Botanicum Medicinale: A Modern Herbal of Medicinal Plants
Endophytes for a Growing World
Herbarium: The Quest to Preserve and Classify the World's Plants
Name that flower - The Identification of Flowering Plants
Orchids of Romania
Population, Agriculture, and Biodiversity: Problems and Prospects
Saffron: A Global History
The Comstocks of Cornell
The Theory of Evolution - Principles, Concepts, and Assumptions
Wildflowers of the Adirondacks

A History of Plants in Fifty Fossils

By Paul Kenrick
2020. ISBN-13: 978-1588346711
US$18.89, 160 pp.
Smithsonian Books



A History of Plants in Fifty Fossils, by research scientist Paul Kenrick, is a beautiful work produced by Smithsonian Books. The book is a basic botanical text, evolutionary biology narrative, and geological work all under one cover. The stunning photography drips from the pages of this information-dense publication. I chose this book because of my admiration for my friend, Karl Niklas, professor emeritus at Cornell University. Karl is a pure educator. The sense of excitement I felt watching Karl teach is the same sense of enjoyment I received from reading Kenrick's beautiful book. "It's not easy being a plant." (Kenrick, p. 5) is the first sentence to the "Introduction," and is a section that should be considered required reading for any introductory botanical or horticultural course. If your botanical sensibilities don't tingle with anticipation right from the onset of this first sentence, then put the book down. Otherwise, read on!

The author has such a delicate mastery of description that when he bids the reader to "imagine," one does just that. One gets an unmistakable feeling of incredulity to read of the preservation of plant tissues, which are transformed over millennia into fragile compounds, that collectively maintain their strength through time and decomposition to reveal their secrets. Kenrick's masterful storytelling of a single cell adapting to its environment to evolve, then adapt again, in a repeated process of growing and strengthening and straightening toward sun on stalk, and with open canopy, is unlike much of what I ever read or learned about these processes. It's refreshing and engaging.

The secrets of a rock that was once upon a time a lithe tree (here Kenrick writes of the *Eospermatopteris*), or an insect captured for all time in its amber cocoon, astonishes with their secrets as one learns of the expansive and pliant adaptations of all of these venerable fossils. Plants, and the animals that ate them, all developed and evolved specialties through the ages to ensure their individual and, by default, collective survival. These adaptations may be seen in the fossils of seed dispersal, pollen preserved within the guts of amber-embedded insects, and coprolites (viz., fossilized feces—if that's a new word for you as it was for me) of early herbivores. Kenrick weaves his tale of plant evolution through seed, fern, and tree cone describing the "living fossil" lineage of the modern horsetail (*Equisetum*) to the possible food (the Cycads) of the dinosaurs.

I love the beautiful fan-like shape of the *Ginkgo biloba* leaf. It is elegant and simple. The leaves shimmer together and have for several millennia, imitating an ancient dance contrived in its country of origin. Long before the steps were choreographed, the *Ginkgo*'s ancestor established its geological history. Reading this history is akin to creating a plait between the cords of climate, seed dispersal tactics, and geography. According to Kenrick, *Ginkgo* has been found on every continent, including Antarctica (Kenrick, p. 80). All terra firma has had this beautiful tree rooted in its worldly soil. Ancient winds once blew through the fossilized leaves much as our zephyrs of today swirl about our Ginkgos. What a thrilling connection to our botanical past!

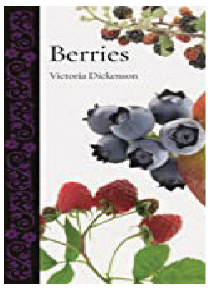
We are time travelers in Kenrick's ship, and with him at the helm we are vividly transported in our mind's eye to the very base of the trees of the fossils he describes. I was transported to, once again, stand before the *Metasequoia glyptostroboides* in residence at the Cornell Botanic Garden in Ithaca, NY. To read Kenrick's history of the dawn redwood, once thought extinct yet pulled from the brink, gives one a thrill of association with the efforts of early botanists. We may all stand before this magnificent tree because of these conscientious scientists, and through Kenrick we realize the significance of the magnitude of these efforts.

Interspersed with the fossilized plants and plant structures are basic, yet elegant, botanical explanations of the principles of xylem, stomata, photosynthesis, decomposition, crystallization, and botanical rebirth and extinction. Kenrick's remark that "...extinction appears to be the ultimate fate of all species" is a haunting phrase that punctuates a section where the reader won't find much comfort in the pointed descriptions of mass extinction and changing ecosystems. For all the academic jollification of this wonderful book, Kenrick masterfully, and soberingly, reminds the reader that understanding the violent extinctions of the past, through these botanical casts, will contextually impress upon the consciousness of our humane influences and impacts on our delicate world.

In the sections following the significant words of extinction is the 13-million-year-old fossilized leaf of an *Acer trilobatum* found in a volcanic crater. This photograph gave me pause for the renewal, and regrowth, of adaptation and plant diversity from pole-to-pole and in-between. The leaves that senesce in our autumnal months are strikingly similar to this ancestor. The organized veg of an Antarctic fossil, and the contrary messy clumping of deciduous leaves in a Saharan sample, fed my curiosity about regrowth from extinction—what a different place the Earth was with not only a green Antarctic, but a green Sahara as well! Kenrick reminds the reader that "by their presence alone, plants can transform their habitats" (p. 100)—and ours as well.

This wonderful book ends with an image index of the 51 specimens exampled and discussed throughout. For any cartographers, there are maps of the Earth through time, and the "gneiss guys" among botanists will appreciate the succinct geological time scale. Through his surreptitious tutelage, Paul Kenrick leads us on an evolutionary journey to ourselves and of the symbiotic relationship we have with the botanica in our world.

–Karen Penders St. Clair, Ph.D.



Berries

Victoria Dickenson
2020. ISBN: 9781789141931
$27.00; £16.00 (Hardcover); 208 pp.
Reaktion Books, Ltd., London, UK, distributed by University of Chicago Press, Chicago, IL.

Victoria Dickenson, Adjunct Professor, Rare Books and Special Collections, McGill University, explored multiple library and museum collections to prepare a delightfully illustrated historical review of berries. Her familiarity with archival resources is demonstrated through charming creations by the famous: Hieronymus Bosch, Lewis Hine, Hokusai, Winslow Homer, Dorothea Lange, and unknown (e.g., the frescoes of Pompeii, buoyed by poetry and prose of eminent modern writers: Emerson, Jefferson, Shakespeare, Thoreau, Tolstoy; and ancient: Aesop, Ovid, Pliny the Elder, Virgil).

Dickenson opens with an essential definition of terms because her book is about culinary berries, distinct from the strict botanical definition of berries, those fleshy fruits without a stone (pit) produced from a single flower containing one ovary. Berries so defined include grapes, currants, peppers, tomatoes, cucumbers, eggplants, and bananas, but exclude certain fruits that meet the culinary definition of berries (e.g., strawberries and raspberries). The latter culinary berries are aggregate or compound fruits containing seeds from different ovaries of a single flower, with the individual "fruitlets" joined together at maturity to form the complete fruit. Examples of aggregate fruits commonly called "berries" include members of the genus *Rubus*, such as blackberry and raspberry. Multiple fruits are the fruits of two or more multiple flowers that are merged or packed closely together. As mentioned in a previous review (Bedigian, 2020), the mulberry is a berry-like example of a multiple fruit; it develops from a cluster of tiny separate flowers that become compressed as they develop into fruit. Strawberry is the aggregate of seed-like achenes, actually the "fruits," derived from an aggregate of ovaries; the fleshy part develops from the receptacle. Here, Dickenson includes among berries all small, bright-colored, edible fruit lacking a pit.

A breadth of subjects is incorporated here. Frugivore bats, birds, reptiles, and insects are all stars. We must beware the snake in the grass when searching for strawberries. Berries often figure in legends and may symbolize love as well as betrayal, as with the strawberry fields in Ingmar Bergman's archetypal classic 1957 film *Wild Strawberries*. Cedar waxwings are almost exclusively fruit eaters; consequently, they have large livers to deal with their occasionally alcoholic repasts, and their extendible throats hold large quantities of berries, including species toxic to humans. This was evident during an icy January in University City MO, when a rush of wings and reedy calls caught my ear. Turning to the window, I observed a huge flock of cedar waxwings that had located the handsome holly grove in my yard. Over the course of two days, they plucked the poisonous fruit, leaving the branches bare of berries.

Generous attention is given to gathering tools, such as berry combs constructed of wood or, along the Pacific Northwest, salmon backbone. A special one is made of steam-curved wood, with the seam bound by a tough walrus thong, and an ivory handle. Contrast those with modest Crisco and coffee cans whose wire handles were carefully wrapped to prevent callouses.

Child labor, upon which the United States relied as the industry grew in the period following the Civil War, is reviewed in the section about cultivating. Human rights are foremost in documenting production; much was borne on the backs of countrywomen. Dickenson depicts Italian immigrants from Philadelphia, Syrians from Boston, and Poles and black Portuguese '*Bravas*' who picked cranberries in Massachusetts, Wisconsin and New Jersey.

Horticultural varieties are many, and efforts to make a better berry favoring size, flavor, and productivity were sought. Dickenson reports in a colorful quote that the blackberry has been called "a primitive thug that has been turning parts of the northern hemisphere into off-limit areas since well before the last Ice Age began, some thirty-five thousand years ago (Jonathan Roberts, The Origins of Fruit and Vegetables)," complaining about brambles. Jams and jellies offer an ancient technology for preserving the harvest, which gave way to the production of "Factory Fruit."

In recent years, their distinctive chemical constituents led to considerable consumption of berries (and the leaves of some species), in a natural pharmacopeia. Berries are recognized as superfruits for their polyphenol contents. Hydroponic cultivation of strawberries saves back-breaking stoop labor during harvest. A Japanese researcher's innovation in the 1990s—thin nutrient films made of hydrogel—"provides everything a growing strawberry needs, resulting in increased yields of very clean berries." However, Dickenson closes with a cautionary note about "industry's increased reliance on plasticulture, pesticides, fertilizers, irrigation and chiefly female labor."

The design of this well-bound book is attractive, featuring a vivid cover photo and signature endpapers—here, the deep purple hue of blackberry pie. Standard features of the Botanical series are included: a brief timeline, reference notes to each chapter, a select bibliography, a list of associations and websites, and a five-page Index. Readers with an interest in nutrition and food trends, as well as horticultural history, will find this volume full of gems. This book is a spectacular success. The illustrations are botanically and culturally relevant and allow the reader to happily wander amidst splendidly curated details.

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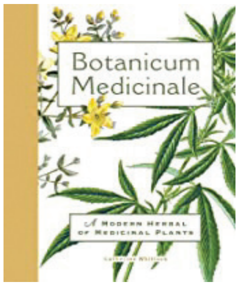
Bedigian, D. 2020. An extended commentary about Mulberry by Peter Coles. *Plant Science Bulletin* 66(2): 145-150.

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



Botanicum Medicinale: A Modern Herbal of Medicinal Plants

Catherine Whitlock
2020. ISBN: 978-0262044479
$29.95 (hardcover); 224 pp.
MIT Press, Cambridge, MA

I have a rudimentary understanding of herbal medicinals and know something of the soothing properties of chamomile for nerves, and of aloe for burns. Wouldn't one consider pineapple, or papaya, a fruit? Cinnamon, or cardamom, spices? Autumn crocus and Lily-of-the-Valley, flowers? Yet, in Catherine Whitlock's *Botanicum Medicinale: A Modern Herbal of Medicinal Plants* (2020), all of these and more fall into an additional herbal medicinal category. Whitlock's book is an interesting read of the common, and not so common, plants carefully chosen for her purposes of education and discussion of a traditional form of therapeutics.

The book's focus is on educating the reader on herbal medicine by making use of any plant part, (i.e., root, bark, leaf, flower, or fruit). Whitlock chose 100 plants to feature based on historical use or modern medical research—all from diverse habitats. Many plants may be familiar to readers depending on where they grew up, or currently live, while the converse is also true. Cotton (*Gossypium hirsutum*) and the May apple (*Podophyllum peltatum*) are very familiar to me as the chamomile mentioned above because I live in a temperate climate. However, this is very different from the Indian Snakeroot (*Rauvolfia serpentina*) and Han Fang Ji (*Stephania tetrandra*), which are either native to the tropics (the aforementioned) or to China (the latter), and neither of which I've visited. This interesting geographical representation of species is one facet that reflects from each herbal to make this work a book of discovery and enjoyment.

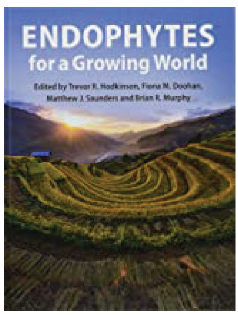
A discussion of the "unbroken tradition of herbalism" (p. 9) includes Ayurvedic and Chinese herbal medicine followed by European, then later American, traditional restorative botanicals. This is not an extensive section, but rather a base for the author to lead into her basic discussions of the plant chemistry of flavonoids (antioxidants found in brightly colored fruits and vegetables), alkaloids (think: bitter taste), or glycosides (a sugar component combined with a non-sugar component). Whitlock is not laying an intricate biochemical foundation, but rather continuing her discussion for the layman. This is one of the reasons why this book is so enjoyable—it allows readers with varying degrees of proficiency to be entertained, or enticed, or both.

Botanicum Medicinale is encyclopedic in its layout. The introductory material is followed by the plant synopsi, and there are five essays inserted for further commentary on garlic (*Allium sativum*), marijuana (*Cannabis sativa*), turmeric (*Curcuma longa*), opium poppy (*Papaver somniferum*), and yew (*Taxus* spp.). The detailed alphabetized contents and index, combined with the comprehensive "Actions of Plants" chart and glossary, ensure that you will find your plant (if it is one of the esteemed 100!).

Whitlock capsulized the breadth of botanical medicinals for her book by choosing select plants, each beautifully illustrated and inclusive of each selection's name (common and scientific), key uses, medicinal uses, habitat and harvest, and, importantly, "Cautionary Notes." This last section emphasizes drug interactions herbals may have with prescription medication, as well as notes on allergic reactions and potential toxicity of their own accord. I believe that this is very smart on Whitlock's part, for this interesting, and visually appealing, work draws the reader in quickly and almost self-servingly.

Whitlock has provided us with a gateway into a specialized garden that has been selectively accessed over the centuries. This book is not a medical treatise, but rather a botanical sampling of an ancient mastery thousands of years old including its uses, and associated folklore, without being prescriptive.

–Karen Penders St. Clair, Ph.D.



Endophytes for a Growing World, 1st Edition

by Trevor R. Hodkinson (Editor), Fiona M. Doohan (Editor), Matthew J. Saunders (Editor), Brian R. Murphy (Editor)
2019;
ISBN-10: 1108471765;
ISBN-13: 978-1108471763
US$140.00 (Hardcover), 444 pp.
Cambridge University Press

An endophyte is an endosymbiotic organism that lives within a plant. Typically, these life forms are bacteria and fungi. *Endophytes for a Growing World* is based on an international conference held in Ireland in 2017 and is a series of interesting review articles (that were peer-reviewed) on basic and applied aspects of endophytes in plants. There are a total of 56 contributing authors who represent a strong group of international scientists in the field.

Every chapter has an extensive list of references that are up to date as of 2018–2019. The reviews contain line diagrams and half-tone images, and the center of the book has selected color plates for the various chapters.

The first chapter is a comprehensive introduction to endophytes, and it is clear that the definition of the term itself is unclear! Throughout the book, while consensus among scientists exists on definitions, there also are some variations on the theme. For instance, some researchers prefer the definition of an endophyte as being beneficial or neutral for the plant. Other workers see endophytes as on a continuum from beneficial to neutral to pathogenic. A further complication is that mycorrhizal fungi have a distinct scientific literature but can be considered endophytes in a broad definition of the term (Dauzart et al., 2016; Genre et al., 2020).

Part II of the book consists of six chapters on the role of endophytes in biotic and abiotic stress resistance in plants. For instance, one review considers the use of some groups of fungi as biological control agents to prevent plant disease in order to improve crop production. The authors point out that some fungi are endophytes in one situation but can be pathogenic in other cases. Another chapter reviews the use of endophytic fungi as a biological control mechanism in barley diseases.

Part III considers the community ecology of endophytes in five chapters. For example, chapter 10 summarizes the ecology of bacterial endophytes in plant leaf tissue. Another chapter in this section considers using a meta-omics approach to study the endophytic bacterial communities in *Brassica napus* (oilseed rape), an agriculturally important plant.

Part IV includes three chapters and provides an interesting perspective on using endophytes as a potential source of novel biomolecules for applications in industry and medicine. One chapter examines the use of endophytic fungi as a source of bioactive compounds. The authors point out that while plants have long been used as natural products to treat human disease, there has been an increased effort in drug discovery using endophytes. The story of the discovery of the cancer treatment drug Taxol from an endophytic fungus in Pacific yew trees is given as a prominent example of the potential of endophytes in drug discovery.

The last section (Part V) focuses on the application of endophytes in crop production and has three chapters. A particularly interesting review considers endophytic bacteria that promote growth of agricultural plants and that have been used in field trials in Europe. Part of the impetus for this research is that the European Union has increased restrictions on chemical use in farming throughout the continent. This author takes an interesting approach in considering political factors as well as looking at the basic biology of these approaches.

This book provides a wealth of up-to-date information on the biology of endophytes and their host plants. While I have done some research on mycorrhizal fungi in ferns and in flowering plants (Swatzell et al., 1996; Lionheart et al., 2018), this book certainly has broadened my horizons. It will be a welcome addition and could be used in advanced classes in plant physiology, medical botany, and horticulture. As such, it is more suitable for advanced undergraduates, graduate students, and professionals.

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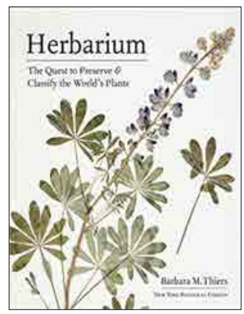
–John Z. Kiss, Department of Biology, University of North Carolina–Greensboro, Greensboro, North Carolina, USA

Herbarium: The Quest to Preserve and Classify the World's Plants



Barbara M. Thiers
2020. ISBN: 9781604699302; ebook: 9781643260525
US$40.00 (Hardcover); 304 pp.
Timber Press, Portland, OR.

Herbarium delivers an expert's perspective with an entertaining account about systematically arranged collections of dried plant specimens amassed for scientific study. The reader is taken on a journey through the history of botanical collecting, led by an author knowledgeable about its many facets. Barbara Thiers—director of the William and Lynda Steere Herbarium at the New York Botanical Garden (NYBG), President of the American Society of Plant Taxonomists (2020-2021), and past-president of the Society for the Preservation of Natural History Collections—is perfectly positioned to introduce the general reader to the particulars and purposes of an herbarium. Thiers is responsible for overseeing the NYBG's 7.9 million collections of algae, bryophytes, fungi, and vascular plants, and the staff who manage these collections. As editor of Index Herbariorum, the guide to the world's approximately 3300 herbaria, Thiers has applied information technology to herbarium management and to increasing access to specimen-based data for the scientific community. These interests have led to the searchable database of digitized herbarium specimens (4.5 million so far, with 400,000 added each year), comprising the Steere Virtual Herbarium.

Thiers' purpose in writing the book is stated as (1) an introduction to herbaria for natural history enthusiasts and for colleagues to share with students, staff, and institutional leaders; (2) to show the wide range of circumstances under which specimens have been gathered and handled after collection; and (3) to engender appreciation for the institutions that made a commitment to preserve specimens in perpetuity.

The impetus for the establishment of herbaria was the number of new plant species coming into Europe during the Age of Exploration. It was nearly impossible to keep plants alive on long sea voyages, so seeds and dried specimens often became the Europeans' first introduction to unknown plant species. Italian physician/professor Luca Ghini (b.1490) advanced the study of plant medicine and created the first herbarium—a book filled with pressed specimens of plants, glued onto the pages alongside annotations about the plant's features, the circumstances behind its collection, its known medical properties, and other facts. "If handled carefully and kept protected from moisture, insects, and light, a dried plant specimen could be preserved in this manner indefinitely."

A synopsis of the contributions of major plant collectors follows, such as William Dampier, an English explorer, pirate, and navigator who became the first Englishman to explore parts of what is today Australia, as well as the first person to circumnavigate the world three times.

Running through the book are examples of the fact that this is a world dominated by men. Those who subsidized the missions—ship captains and high-ranking officials—took a dim view of women. A remarkable brave and determined pioneer of plant exploration whose experiences piqued my curiosity is Jeanne Baret, who accompanied naturalist Philibert Commerson. Disguised as a man on the 1676–1679 French expedition of L.A. de Bougainville as his valet, Baret kept her identity hidden from all but Commerson for many months. Baret proved herself capable of demanding manual labor. She was invaluable in assisting Commerson as his slogger, collecting botanical specimens when Commerson's health had failed, although she received no acknowledgement as collector. Baret also organized his collection and papers, of which he was neglectful, and ultimately became the first woman to circumnavigate the globe.

Although Thiers relied on Ridley (2011) in retelling Baret's role, some, including Gimson (2014), Helferich (2011), Knapp (2011), and Lack (2012), have questioned Ridley's speculations; perhaps some of their concerns were overlooked. Dunsmore's 2002 biography seems to be more factual but is presently unavailable in bookshops; only six copies exist in the United States, at the Library of Congress and universities. Reviewer Philippa Jamieson wrote: "[Dunsmore] outlines the historical context, and details life on board an eighteenth-century sailing ship: the cramped conditions, rats, dwindling supplies, scurvy. He has been assiduous in his research; the book includes diary excerpts, footnotes, an index and bibliography."

A major dilemma for many herbaria surfaces in Thiers' effective and cautionary description about the plight of the Lewis and Clark herbarium: "The specimens follow the same sorry trajectory of those by early European explorations—the specimens were gathered and preserved with great effort through the course of a difficult journey, only to be forgotten and neglected later, due to the weakness of the scientific infrastructure."

A debated preference amongst taxonomists figures in Thiers' description of Rafinesque's penchant as an extreme splitter, who based new species on slight variations in leaf shape or size, or flower color; thus, most of his species names are now disregarded.

Herbarium is intended, according to the author's preface, to provide context for readers lacking knowledge about historic plant explorations or herbaria. Thiers tracks the evolving discipline of plant taxonomy, including the practical roles that herbarium specimens play, e.g., now enabling research using genomics tools, that may even provide information about extinct species. Naturally, readers will assess the book as it relates to their specific disciplines. For this reader, it seems that the information researchers glean from herbaria deserves more emphasis: (1) labels hold significant indigenous knowledge about medical, edible, fiber, and ritual uses of plants (Von Reis and Lipp, 1982; Bedigian 2004a, 2004b, 2013a, 2018; Nesbitt 2014); (2) a major source for species discovery (e.g., Bedigian, 2013b); (3) vernacular names help to trace trade (Bedigian, 2004a) or (4) confirm occurrence at a specific location (Bedigian, 2011); and (5) facilitate an understanding of how climate data (heat, drought and insect outbreaks, extreme rainfall patterns) are affecting species composition, or adaptations to new environments.

The range of topics covered depict social and geographic, as well as botanical, history. *Herbarium* is a useful resource for students, educators, and natural history enthusiasts with an appetite for travelogues and the history of plant exploration. This well-bound, profusely illustrated hardback belongs in every library with any focus on biology. Thiers' style is easy to read; specialist terms are defined. It's a hefty book with attractive moss green cover and bright yellow endpapers. Thiers presents a useful introduction that assembles a series of significant events in the history of plant collecting and the people who made it happen, correlated with world affairs. Those vivid stories bring specimens to life.

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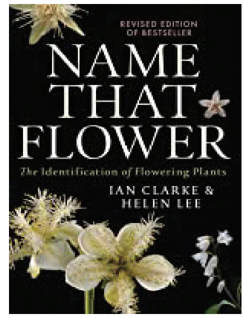
–Dorothea Bedigian, Research Associate, Missouri Botanical Garden, St. Louis, Missouri, USA

Name That Flower: The Identification of Flowering Plants, ed. 3



By Ian Clarke and Helen Lee
2019. ISBN: 9780522876048
US$39.99; 374 pp.
Melbourne University Press

"What is the importance of naming flowers?" one might ask. In fact, I was asked this same question very early in my career. I remember sitting in an introductory systematics class as a first-year undergraduate student at the University of São Paulo in Brazil. My instructor at the time was Dr. Renato de Mello-Silva, a bright and inspiring botany professor and herbarium curator in my institution. He, unpretentiously, asked the class a simple question after presenting a picture of a tree: "What's the name of this tree?" Nobody knew. He continued by saying that if you cannot name that tree, it simply does not exist. He explained that as long as biologists do not name and describe species, no one could accurately study and refer to them. That powerful line has been stuck in my memory since that day, and the book *Name That Flower* reminded of me that moment.

The introductory chapter provides the readers with a background on land plant evolution; it discusses the historical relevance of plants and emphasizes their economic value throughout human history. It also covers the overall organization of the book and some essential pieces of information on how to use the book. Chapter 2 describes very objectively the structure of flowers without omitting crucial details and exemplifies the concepts with great illustrations. Although this chapter is very technical and detailed, it is also very pleasant to read.

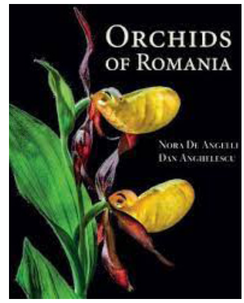
The remaining chapters of the book are focused on describing the major land plant families that are common to southeastern Australia. Helpfully, the authors included a key morphological trait that is easy to spot for every family. The plates are especially visually appealing; the images are detail-rich and provide different angles and points of view of the flower parts. The book also contains a brief key for identifying plant species, focused on identifying the species illustrated on the plates.

The book proposes a traditional approach to plant identification in which the reader should be outdoors with tweezers and scalpels dissecting a flower to run a dichotomic key. But the authors also acknowledge the wonders of recent advances in technology in which books and guides can be accessed online, the pictures can be magnified, the keys can be interactive, and museums and herbaria can be visited remotely from everywhere. The concepts and skills that one could obtain from this book are easily transposable to other books or keys that cover plant species from any other region in the world. I consider the chapters on morphology and the stunning illustrations especially relevant. In summary, I definitely recommend this book for casual plant enthusiasts and professionals alike.

–Aline Rodrigues de Queiroz, MS, Biochemistry Department, University of Nebraska-Lincoln

Orchids of Romania

Nora De Angelli and Dan Anghellescu
2020. ISBN: 978-973-0-32586-7
US$75.00 (Hardcover); 300 pp.
Snagov



Beautiful books containing good descriptions and excellent photograph of spectacular tropical orchids are common. Much less common are similar books that deal with temperate climate orchids, which are mostly terrestrial, small, and often not attention grabbing. This book (full disclosure: the authors sent me a copy, graced with a flattering inscription, as a gift) belongs to the latter category.

A problem with temperate climate orchids is that their flowers are mostly small, even if they're as beautiful as their large tropical cousins. Because of that, they are hard to notice even in their natural habitats, and they're not easy to see and appreciate. The authors overcame this problem by using macro photography (with Nikon and Canon cameras and lenses; my lifelong experience and bias are that Micro Nikkor lenses are hard to beat) and the relatively new technique of photo stacking. This technique consists of combining many images (sometimes as many as 100) in a single photograph to obtain greater depth of field, which decreases as magnification increases. Examples of this are the anther details on pages 177 and 181, and flower and labellum details on pages 257, 261, 263, and 283. (This information was provided via email by the first author.)

The photographs are very sharp; the ones on pages 22 and 182 and inside the front and back covers are spectacular. Most photographs are properly cropped to emphasize the orchid. The background of those that are not cropped is: (1) just enough out of focus to create pleasant bokeh resulting in photographs that are artistic but still draw attention to the orchid, or (2) informative regarding habitats and other plants near the orchid.

In addition to photographs of orchids only (flowers, inflorescences, plants, habitats), there are also images of visitors (pollinators, robbers, predators, visitors who came to rest or feed, and ones who just happen to be there). On page 10, six interesting photographs illustrate the pollination sequence of Cypripedium calceolus by a solitary female Lasioglossum bee. In Asia and tropical America, predatory spiders associate with orchid flowers, mimic them, or hide near/in them to prey on pollinators. (I saw one in the Bogor Botanical Gardens in Indonesia; its web was very hard to see, and my student there at the time, the late Djunaidi Gandawijaja, had to squirt a fine mist of water on it to make possible a now long-lost photograph.) Some Romanian spiders also prey on orchid visitors. A yellow spider waiting for small insects was photographed on the same color pouch of C. calceolus (p. 10). A butterfly on an Anacamptis palustris is oblivious to a hard-to-see spider, which was probably stalking it (p. 47) and may have made a meal of it since the photograph was taken. On page 255, a crab spider on Neottia ovata feasts on a garden chafer.

Altogether, the photographs create a magnificently illustrated, visually attractive, and botanically instructive book—a rare and very welcome combination. A drawback is that the photographs do not contain size indications either as a magnification factor (the usual "×" followed by a number in the caption) or a scale bar on the image. Size indications are especially important in this case because the orchids are small and some are magnified in the photographs.

Descriptions of genera and species are sufficient to acquaint readers with the taxon, which is being described without including many of the boring, and sometimes numbing, terms favored by taxonomists. The meanings and/or origins of generic, specific, and varietal epithets are always explained. Where appropriate, legends, mythological information, usage details, and historical data are also included. All are clear and easy to read. A problem with the descriptions is that information about size and dimensions is not included. It should have been.

The origin of the term "orchid" is usually attributed to the ancient Greek, so-called Father of Botany, Theophrastus (371–287 BC) who saw a similarity between mammalian testicles (*orchis* or, as listed in the book, *orkhis,* a spelling I saw for the first time; I do not know which is correct). There is even a story of goat sperm that fell to the ground during copulation and fermented into orchids. Most authors (including myself) usually just repeat these stories. Not the authors of this book. They tell a little-known (by me, also) story, the *Myth of Orchis*. It is of *Orchis*, the son of a satyr and a nymph, who attempted to rape a Dionysus (the Greek god of wine) favorite. Angered by this, the Maenads, female followers of Dionysus, tore him apart. *Orchis*' father begged the gods to revive him, but they refused; instead, they transformed his testicles into the root tubers of an orchid, which was first called *Satyrion* and later became known as *Orchis.*

Enough literature is listed in the References and Bibliography to allow those who are interested in further reading to do so. I am especially pleased that papers by A. Fuch and H. Ziegenspeck are cited. These two friends (at least one of them was a pharmacist, if memory serves correctly) studied German native orchids extensively and published very long and detailed papers (largely forgotten at present) in the mid-1900s in the *Botanisches Archiv* and its *Beihefte*. When Fuchs died, Ziegenspeck wrote a touching obituary of his friend and continued to work by himself for a while. However, I was disappointed not to see in the References and Bibliography Bertil Kullenberg's seminal work on pseudocopulation and ultraviolet reflection images of *Ophrys*. His ultraviolet reflection images may well be the first application to orchids of this type of photography. M. Pouyanne, president of the court in Sidi-Bel-Abes in Algeria, who first described pseudocopulation in *Ophrys speculum* in 1916, is cited.

An interesting feature for those interested in both orchids and postage stamps is on pages 296-297: Photographs of Romanian postage stamps that feature orchids. Many countries (including the United States) publish postage stamps that bear photographs of native orchids, but few local-orchid flora books mention them.

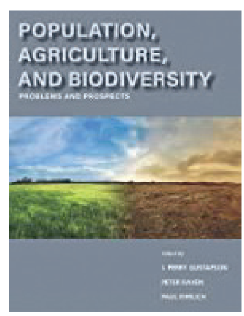
The last page of the book contains two photographs of the kind one does not generally see in orchid books. One photograph is of the author and her very handsome Belgian Malinois (spelled in the book as Malionois) dog, Ringo. The other is of Ringo alone. He, according to the author "is probably the only orchidolois (*sic*) Beligian Malionois (*sic*) in the world." Probably so. As a dog lover, I welcome what may well be the first acknowledged canine orchidologist and look forward to many more. Why not? Orchids have been connected with dogs in the English language for a long time. In describing Ophelia's garland in *Hamlet*, Shakespeare refers to "long purples"—probably *Orchis mascula,* which has the "grosser" name "dog stones" because its roots are shaped like testicles (the use of "stones" to mean "testicles" is ancient according to the *Oxford English Dictionary*).

I was disappointed to note that the book has no index. A large (a heavy 300 pages measuring 28.5 cm H × 23.5 cm W × 2.3 cm thick), complex, diverse, informative, and meticulously produced book like this one should have a very detailed, extensive, and comprehensive index.

Altogether this is a beautiful and interesting book that presents temperate climate European orchids excellently in text and photographs. It would be appropriate in general botany and/or orchid specialists' libraries (I am certainly glad to have it in mine), and/or to grace any coffee table. Romanian consulates and embassies should have it in their waiting and/or reception rooms because it may attract visitors who are interested in orchids.

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

Population, Agriculture, and Biodiversity: Problems and Prospects



J. Perry Gustafson, Peter H. Raven, and Paul R. Ehrlich (eds.) 2020.
ISBN: 978-0-8262-2202-2
US$45.00 (Hardcover),
398 pp.
University of Missouri Press, Columbia, MO

Since the recognition of Planetary Boundaries (Rockström et al., 2009), we have had a tool to evaluate human impact on the biosphere. What usually goes unsaid, however, is brought to the forefront by the editors in their introduction. There is a single underlying cause for all of these existential problems: "If our goal is environmental stability, we really need to limit population growth" (p. 2). The editors go on to summarize the problems and approach of the book as they introduce the topics that will be covered in the subsequent 15 essays. In the next 30 years, agricultural productivity will have to increase by 2.5% to 3% to feed the estimated 9 to 10 billion people, yet agricultural production currently contributes about 21% of greenhouse gases and nearly 40% of the methane, contributing to climate change. Between 500 and 2000 L of water, as well as large amounts of chemical fertilizers, pesticides, and herbicides, are necessary to produce 1 kg of grain, half of which is fed to animals, while runoff and percolation contaminate surface and groundwater. Biodiversity is lost as croplands replace forest and grassland. All of these intricate relationships are addressed in this volume, and while many are familiar to our professional community, the authors and editors have done a good job of integrating the complexity in a way that can be presented to the general public. What I found especially useful was the integration of the agricultural, economic, and social perspectives throughout the book, not just in specific chapters.

Paul and Anne Ehrlich set the stage in the first chapter with an overview of the current state of the problem with considerations of how the interconnection of human nutrition, the environment, economics, resources, and politics affects and is affected by population growth. I found the most encouraging chapter to be Nina Federoff's treatment of the possibilities and probabilities of feeding 10 billion people. She begins with a brief history of agriculture, from crop domestication through crop improvement by breeding, the mechanization of agriculture, and the Green Revolution. This segues into a series of sections describing molecular genetic modification of crops and technological innovations in production as tools to do more with less. She is enthusiastic about the possibilities, but realistic about the cultural pushback and need for more effective education. Success will "require both cultural changes in how we view food and substantial increases in educational level worldwide, both of which present challenges as great as that posed by the necessary technological advances" (p. 55).

Specific problems impinging on agricultural production, and their possible solutions, are the focus of the next 10 chapters. These include the role of trade, climate change, tropical deforestation, increasing yield in grain crops, physiological breeding, wild ancestors and breeding, genome engineering techniques, insecticide, fungicide and herbicide resistance, and water. A new, and particularly appropriate, concept for me was that of "wicked problems," introduced in the chapter "Feeding a world in the wake of climate changes and resource constraints." As defined by Batie (2008), "…wicked problems tend to be intractable and elusive because they are influenced by many dynamic social and political factors as well as biophysical complexities." This book is ultimately a case study of the wicked problems that must be solved in the next half-century.

The final three chapters focus on loss of biodiversity: the impact of livestock, agriculture, and pollution in the environment, and direct impacts of agriculture on biodiversity. I particularly liked Pimm's treatment of extinction in the last chapter. His approach is reminiscent of *The World According to Pimm* (2001), where he uses real, but simplified (rounded), data to calculate concrete values to illustrate theory. In the sections on "How fast are species going extinct" and "How fast should they go extinct," he introduces the concept of extinctions per million species-years (E/MSY) with an example from the birds he knows well. Thirteen of the 1230 species of birds known in 1900 were extinct by 1980. This cohort of 1230 species, over an 80-year period, accumulated about 98,400 years, so the extinction rate is $13 \times 10^6 / 98,400 = 132$ extinctions/million species years. Calculation of the background rate is more complex, but the result is <1 E/MSY (~0.1 E/MSY). Where do extinctions occur, where is biodiversity high, where do we find agricultural lands, and what happens when these collide are the questions addressed in the remainder of the chapter.

Many of the 45 figures and 15 tables, distributed among two thirds of the chapters, will be useful for teachers. Derek Byerlee's chapter on agriculture and tropical deforestation is particularly useful as he compares the trends in plant oil and livestock production over time and by region as well as how they are affected by market supply and demand, commodity value, state policies, local initiatives, and individuals' participation. Equally comprehensive is the multi-authored chapter on livestock impact on biodiversity. A projected 20% increase in meat, eggs, and fish production in the next 30 years was not surprising, but I was not aware that milk production was more than twice the total of all of the above in 1980 and is still projected to be 20% more than the total of meats, eggs, and fish in 2050. The book is full of little gems of information I will add to class notes for several of my courses. If you teach general education, you will want this book on your shelf and in the school library. Several of the chapters, by themselves or in groups, could be the scaffold for a graduate research seminar. I recommend it very highly.

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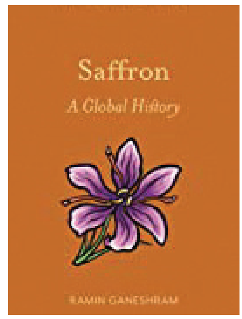
–Marshall D. Sundberg, Roe R. Cross Professor of Biology, Emporia State University, Emporia, KS.

Saffron: A Global History

Ramin Ganeshram
2020; ISBN 9781789143300
US$19.95 (Hardcover),
142 pp.
Reaktion Books, London



Saffron, by food writer and professional chef Ramin Ganeshram, is a new addition to Reaktion Books' Edibles series. Targeted to epicures, Ganeshram promotes the "preciousness of saffron," literally worth its weight in gold. As with other books in this series, this book does not exceed 150 pages in length, resulting in a short summary rather than a comprehensive reference work.

Keeping to its subtitle, *Saffron* is organized into short chapters titled: "Origin and Early Cultivation," "Ancient World and Silk Road," "Medieval and Renaissance Eras," "North America and Caribbean," "Arts and Medicine," "Modern Market," and "A Saffron Primer." Although it includes attributes of a scholarly book: select references, a brief bibliography, and succinct index, the target audience for this book is not an academic reader. Instead, the audience may range from foodies to laypersons interested in a history of globally consumed foodstuffs.

Ganeshram offers a brief overview of the biology of the plant—its origin, varieties, and production—and then shows how saffron became a global commodity. She shows varying roles that saffron plays in different countries, citing a variety of festivals, myths, and practices, brightening the chapters with anecdotes and details about numerous preparations using saffron. As saffron is the most expensive agricultural commodity in the world, it ranks among the most adulterated food items internationally. The reason for its hefty price is its labor-intensive harvest, which cannot be automated. Saffron is revered for its medicinal properties to enhance libido, boost mood, and improve memory, along with numerous treatments that have been investigated in controlled studies (Mousavi and Bathaie, 2011; Poma et al., 2012; Christodoulou, 2015; Hosseini et al., 2018; Cardone et al., 2020).

As regards antiquity, Ganeshram relies heavily on Day (2011) and Dewan's (2015) thoroughly documented research for her Introduction. Notwithstanding, she writes (p. 9) that "Saffron traces can be found in cave art in Mesopotamia dating back at least 50,000 years," a claim of momentous significance, if correct. Unfortunately, she cites no publication attesting to this fact, and my own searches for confirmation found none. One would have to infer that saffron was used as a pigment for cave art by Neanderthals, many centuries before the earliest date (6th–5th millennium BCE) for Sumerian civilizations. The next question is, would water soluble saffron pigment persist for 50,000 years?

Adding to the confusion, the book's back cover also postulates: "Traces of saffron can be found in 50,000-year-old cave art of Mesopotamia." Ganeshram may be referring to an image illustrating a woman collecting saffron stigmas designated "Saffron Gatherer" from the excavation of the Bronze Age Minoan town Akrotiri on the island of Santorini, Greece. Sometime between 2,000 and 1,600 BC, the Minoans arrived in Santorini and settled in Akrotiri. Its strategic location enabled that Minoan city to develop with public buildings, streets, stone houses, markets, and even a sewage system. The frescoes of Akrotiri are renowned for their vivid colors and beautifully preserved depictions. Ganeshram appears to conflate Mesopotamian with Minoan or Mycenean civilizations, which are entirely distinct geographically, temporally, and culturally.

Most cave paintings date to the Upper Paleolithic, which begins ca. 40,000 BC in the Near East. Prior to this period, Neanderthals were the inhabitants of this area, although cave art is not associated with them (Shipley and Kindscher, 2016). The most famous Mesopotamian site is probably Shanidar Cave in Iran (Sommer, 1999).

Paleolithic artists seem to have used two main colors, although others have been found in some cave art. The dominant two are red (which tends to be iron oxide: natural hematite or heated goethite) and black (charcoal or manganese oxides) (Siddall, 2018). What is the likelihood of saffron pigment surviving 50,000 years? Saffron pigment is primarily produced by crocin (chemical composition: $C_{44}H_{64}O_{24}$) (Bathaie et al., 2014), one of the few naturally occurring carotenoids, and is *easily soluble in water*. This water solubility is one of the reasons for its widely preferred application as a colorant in food and medicine. Therefore, its persistence for 50,000 years on impermeable rock seems doubtful.

Admittedly, this is the first in Reaktion Books' Edibles series that I have read; it may serve some general interest, but I hesitate to recommend this book to librarians or students. Their Botanicals series seems to be directed to more serious readers, written by authors who, in most cases, are experts in their fields.

Overall, the book introduces the long history of saffron and the many ways in which cultures have valued saffron as a spice and a symbol. It is an accessible resource, nicely illustrated with 48 color plates; of particular note, these include botanical prints, the frescoes of ancient Santorini, Mogul-era miniatures, saffron-hued robes of Buddhist monks, and photographs of recipes starring saffron. Twenty pages of recipes close the book.

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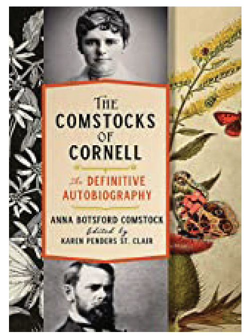
–Dorothea Bedigian, Research Associate, Missouri Botanical Garden, St. Louis, Missouri, USA

The Comstocks of Cornell: The Definitive Autobiography



Anna Botsford Comstock
(Editor: Karen Penders St. Clair)
2020.
ISBN: 9781501716270
US$39.95 (hardcover); 532 pp.
Comstock Publishing, Cornell University Press

What if you realize that a published autobiography is noticeably different from the manuscript that the autobiography is based on? If you have a penchant for naturalist educator Anna Botsford Comstock, who in this case wrote the manuscript, and you are a doctoral candidate at Cornell University, you might give thought to restoring and reconstructing Anna Comstock's voice in its entirety. Karen Penders St. Clair did just that with her newly edited publication, *The Comstocks of Cornell: The Definitive Autobiography*. Her work to revise and update Anna Comstock's diaries took five years of archival research and a patient, sentence-by-sentence comparisons of Anna's original manuscript to that of an autobiography published in 1953. The result is a noticeably longer text and a grand look at how biologists and biology educators worked, long before the arrival of electron microscopes and genome sequencing.

Who were the Comstocks? John Henry Comstock founded Cornell's entomology department in 1876. His wife, Anna, worked alongside him, supplying many illustrations for his publications. Anna later became a nature-study professor in charge of summer institutes for teachers and writing for a myriad of Cornell's nature-study publications. The Comstocks were instrumental in founding the Comstock Publishing Company in 1892, mainly to publish their own books. One of these books, the *Manual of the Study of Insects* (1895), essentially put John Henry, the writer, and Anna, the illustrator, on the map.

As a relatively self-taught artist, and a good one at that, Anna worked with water color and pen-and-ink mediums before learning wood engraving to provide illustrations for the Comstock's publications. Anna is best known for writing the *Handbook of Nature-Study for Teachers and Parents* (1911). While teaching and illustrating, Anna also started a diary of sort in 1914 and continued documenting her life at Cornell through the late 1920s. Before her death in 1930, she typed her diaries and her husband's biography into a manuscript suitable for publication. Upon John Henry's death in 1931, all of the Comstock's papers were transferred to a new owner, Glenn Herrick, an entomology professor at Cornell and Anna's cousin.

Herrick saw fit to publish Anna's manuscript, and friends of the Comstocks urged Herrick to publish Anna's autobiography in its entirety. Their sentiments did little to influence Herrick or Woodford Patterson, director of Cornell University Press. Patterson did not think Anna's manuscript was scholarly enough and he saw no future for its publication unless the manuscript was heavily edited with a focus on academic work. Herrick seized upon Patterson's suggestions (which were much in line with his own) and, acting as the book's primary editor, removed nearly 215 pages of Anna's manuscript along with changing Anna's language and tone.

The archived manuscript that Penders St. Clair worked from was the heavily marked-up manuscript used by Herrick and Patterson. In some cases, whole pages and chapters were absent. In particular, Chapter 14's focus on nature-study education was missing. The discipline that Anna is most known for while she taught at Cornell is apparently lost and explains why you might be disappointed in seeing so little discussed about nature-study in Anna's own words.

The new autobiography consists of 20 chapters and includes a rededication with Anna Comstock placed front and center. Penders St. Clair opens with an introductory explanation of her editing process and the changes that she made to the 1953 text. Each chapter includes a short introduction written by the editor. In doing so, Penders St. Clair allows her voice to be heard along with Anna's. The first three chapters of the book deal with John Henry's childhood and arrival at Cornell. Chapter 4 revolves around Anna's early childhood through her early 20s when she became a student at Cornell. Anna grew up in Otto, New York, where her love of nature was set by her mother, while a sense of duty and work came from both parents who were successful farmers. John Henry's childhood was quite the opposite of Anna's in terms of stability. His widowed mother could not afford to feed her family and sent John Henry to live with various relatives, none of whom seemed to take a liking to the young boy. John Henry was eventually taken in by a family who treated him as their own son. They encouraged him to work and save money for college. It was at Cornell that instructor John Henry Comstock met student Anna Botsford, and the rest of the chapters detail their lives together at the university.

Anna's writing is stoic, as setbacks with publishing and close friends leaving for war in Europe are treated somberly and with little emotion. She describes much about her husband's entomology work and less so about her own, but we must remember that her details about the nature-study movement were most likely destroyed by Herrick. Nevertheless, Anna's descriptions of her husband as a Department of Agriculture entomologist, his return to Cornell and a new laboratory, and the Comstock's long-lived association with Stanford University provide a deep look into American science in the late 1800s. The two seemed to always be writing, researching, and teaching—so much so that they had live-in caretakers and cooks. Never having children, they welcomed many Cornell scientists and graduate students to board with them. It is apparent that Anna was always focused on a relationship-rich life, whether with faculty or students new to the university. This is one of her lasting legacies.

The 1953 autobiography ends with Chapter 20 and curiously, the one-page entry supposedly covers Anna's writing from 1926 through 1930, ending with a short description of another stroke suffered by John Henry. One is left to wonder what Anna's life was like after her husband was bed-ridden. Penders St. Clair restores Chapter 20 in its entirety and provides a most welcome editor's epilogue that gives more archival information about the last year of Anna and John Henry's lives in Ithaca.

So, who might find this new autobiography interesting? Certainly, anyone who studies the history of science will find nuggets of information about the rise of American science departments and AAAS history. Those interested in nature-study and early science education will also find this book worthwhile. And since Anna does not just write about academics, this book provides context to what a rural life was like at the turn of the 20th century. By restoring Anna's voice, Penders St. Clair throws a wide net to a broad audience. She allows us to see the many facets of Anna's drive to maintain human connections in her academic and her social life, and how these connections drove her success. A model thought for today's modern academic world.

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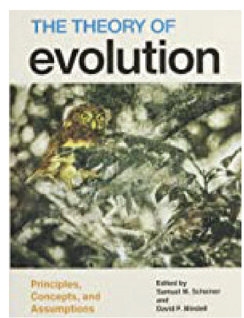
-Karen Wellner, Chandler-Gilbert Community College



The Theory of Evolution: Principles, Concepts, and Assumptions

Samuel M. Scheiner and David P. Mindell, eds.
2020.
ISBN 13:978-0-226-67116-1
US$45.00 (paper). 442 pp.
The University of Chicago Press.

In Chapter 15, Edwards, Hopkins, and Mallet state: "There are many communication difficulties between empiricists and theoreticians in the realm of speciation." This seems to be a fair assessment of the entire field of evolutionary biology, and it is a problem squarely addressed in this volume. The editors assembled a team of 22 contributing specialists to flesh out a formal statement of contemporary evolutionary theory from a variety of perspectives, but always with a firm philosophical basis.

The organization of the book is explained by the editors in the first chapter. The goal is to provide an explicit philosophical framework for evolutionary theory that both connects to the other broad general theories of biology, such as cell theory, genetic theory, or ecological theory and provides a scaffold to connect constituent theories such as natural selection, multi-level selection, and phenotypic plasticity. They also explain the hierarchy of theories, and their components, that will guide the authors of the subsequent chapters. Overarching issues that cross multiple specific theories are the focus of the next seven chapters, wheres the final nine chapters formally address nine constitutive theories that are the focus of most empirical research. The authors of the later chapters follow a uniform model in which they clearly define the domain of the concept they are covering and provide the specific propositions that support that concept, along with appropriate models and examples. I will expand briefly on just a few of the chapters in both sections that I found most interesting and/or provocative.

In Chapter 2, Betty Smocovitis divides the long history of evolutionary thought into five pivotal moments and provides an extensive bibliography to previously published historical and philosophical works that can provide expansive details to the summary story she provides. Not surprisingly, the first pivotal moment centers around Darwin and his works. Pivot two is circumscribed by the rise of Mendalism and corresponding "eclipse" of Darwinism and the founding of the "Modern Synthesis"—notably by Dobzhansky. He is the bridge to pivot three, in which the traditional biological disciplines converge to produce the field of evolutionary biology and the mature Modern Synthesis. Pivot four is the Darwin centennial and the "growing orthodoxy" of adaptationists and selectionists. Pivot five begins as a reaction to this orthodoxy with the advent of molecular and cladistic tools, leading to a call for an expanded synthesis that includes the content of several of the final chapters of this book. Bits and pieces of this story are well known by most of us, but this retelling of the complete story, in five "chapters," provides useful perspective.

Other chapters in this section focus on philosophy of evolutionary theory, modeling, traits and homology, nature of species, trees and episodic synthesis, and evo-devo. Alan Love's chapter on evolutionary development, although the final chapter in the first section of overarching issues that cross multiple general theories, also has a major section treating evo-devo as a constitutive theory. Love's aim is to argue the alternative placements within the theoretical hierarchy. He begins by arguing that evo-devo research has two distinct trends: (1) the evolution of development (changes in ontogeny over time) and (2) the developmental basis of evolution (the regulation and signaling resulting in different developmental pathways). Given the breadth of developmental studies, Love chooses to analyze the evolution of novelty as a specific example. He argues that there are two alternative approaches to analyzing the structure of evo-devo, and specifically the origin of novelty, as a general theory. The first is to begin with concrete practice: how concepts and terms are being defined based on different experimental approaches. Then, what are the problematic assumptions that arise as a consequence? Presumptions about the underlying theory can be guided by the experimental results and assumptions. Alternatively, the abstract theory can be constructed first, as modeled in several chapters, and used to guide inquiry. Both approaches have been used successfully in multidisciplinary studies.

Love goes on to explain that evo-devo can also be approached as a constitutive theory within the general theory of evolution, since it ties directly to variation. His primary example is the eight principles underlying Sean Carroll's genetic theory of morphological evolution (Carroll, 2008).

The constitutive theories addressed in the second half of the book include: Natural Selection, Multilevel Selection, Evolution of Life Histories, Ecological Specialization, Phenotypic Plasticity, Sex, Speciation, Biogeography, and Macroevolution. I found these to be the most interesting chapters but will focus on just one, phenotypic plasticity. This is in part because of my personal interest, but also because, according to the author, Samuel M. Scheiner (who is also co-editor of the volume), this chapter is the first full presentation of a formal constitutive theory of plasticity. All of the other theories (chapters) in the book have been formally addressed previously by one or more authors (p. 258).

The concept of phenotypic plasticity is relatively recent (since the 1980s) and has generally been approached from one of two perspectives: (1) the effect of plasticity on different traits or processes or (2) as a mode of adaptation to the environment. Scheiner focuses on the latter as he develops his theory. The domain of the theory is "evolutionary change in trait plasticity in response to natural selection." The first four propositions relate to the environmental conditions necessary for the adaptive evolution of plasticity. In short, there must be environmental variability that affects phenotypic expression, and optimal phenotypic expression varies in space in time. However, plasticity is not necessarily optimizing and selection can act on either individuals or lineages. Although it seems obvious, the third proposition is that individuals or lineages must be exposed to the existing environmental heterogeneity and, finally, trait plasticity must be heritable and meet all of the other criteria for natural selection. The last three propositions address the conditions that prevent adaptive evolution, the costs of plasticity, and the limitations, either sensing an environmental cue or resulting from developmental limitations. Scheiner presents specific examples for each of these along with appropriate references, although he notes that additional empirical data are needed to determine the relative importance of costs vs. limitations, and this is the weakest link in the theory: "The theory of the evolution of phenotypic plasticity is an interesting case of a mature theory where a related empirical literature is very large, yet where those theory and empirical realms interact hardly at all (p. 271)."

The Theory of Evolution is a deep read for an evolutionary biologist, like myself, whose focus has always been empirical. But it raised questions and illustrated connections that in retrospect should have been obvious, but which I never really considered on my own. For that it will be a useful addition to every evolutionary biologist's bookshelf and an excellent subject for a graduate reading seminar.

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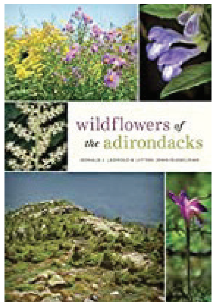
–Marshall D. Sundberg, Professor, Department of Biological Sciences, Emporia State University, Emporia, KS.



Wildflowers of the Adirondacks

By Donald J. Leopold and Lytton J. Musselman
2020.
ISBN-13: 978-1421-43110-9
US$24.95, 346 pp.
John Hopkins University Press

I have a lot of books, and especially field guides, since I believe it's useful to be able to compare descriptions and photos to aid with identification. So I was surprised to flip to the references in this book and not find the original Adirondack wildflower guide by McGrath and Treffs. The two guides have a lot of species overlap but are set up very differently in content. Maybe the authors have not reviewed the previous text; that is beyond my scope of knowledge. Both books are meant to be field guides with the McGrath and Treffs book covering fewer generalists.

The McGrath and Treffs book includes several differences from Leopold and Musselman, including a glossary, visual glossary, and color plates instead of photos with each description. The grouping is also different that it lumps white with pink as a group and purple, red, green, yellow, orange, and blue all together as a group. The descriptions are technical in nature and include flowering period and measurements.

The Leopold and Musselman guide is less technical and includes the opinion that Dichotomous keys are "an identification method devised by people who don't need the keys for people who can't use the keys." I think all of us have flipped to the photos more than once to figure something out quickly, so it's hard to argue with that assessment. The authors begin with an introduction to wildflowers and state-protected plants of the region, then describe plant community types and commonly-associated species. That section leads into an in-depth discussion into groups of Adirondack wildflowers with a focus on groups that are less common in other areas of the state. Orchidaceae is a diverse group in this region, and the section discusses biology and pollination of these sought-after flowers. After these group overviews, the species accounts are broken out by colors. Color groups are tabbed at the top of the page yellow to orange, red, pink to purple, purple to blue, white, and green. Each description includes a photo of that flower, and for some species name origin and similar stories provide interesting anecdotes. The accompanying photos are clear and bright and show the flowers well. The authors encourage the reader to flip through the photos to find their identification. This guide would be good for the casual observer to provide a quick reference to aid them with identification. The authors have purposely avoided being technical and "avoided botanical jargon" and made this guide with that in mind. I think this guide would be useful to hikers and anyone looking to explore this region. Small whorled pogonia (*Isotria medeoloides*) is listed as threatened by the United States Fish & Wildlife Service and not endangered as it was re-classified in 1994. The authors list it as nationally endangered, which is a minor oversight but one worth clarification from page 4. It is listed by the State of New York as an endangered species and was re-discovered in New York in 2010 after being considered extirpated.

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-David W. MacDougall, CWB®, PWS - Consulting Biologist

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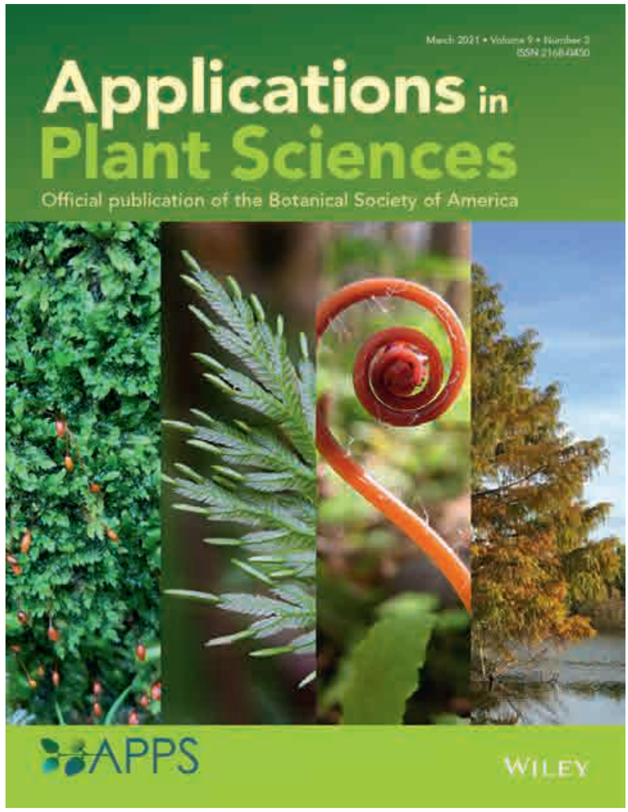

The March issue of *Applications in Plant Sciences* launched a new cover design, which features an image that corresponds to an article from a current or recent issue. The inaugural cover image highlights an article published in the January 2021 issue by Breinholt et al.: "A target enrichment probe set for resolving the flagellate land plant tree of life." This article introduces GoFlag 451, a new target enrichment probe set to help resolve phylogenetic relationships and unravel evolutionary history across the flagellate land plant taxa. With over 30,000 extant species, flagellate plants contain several diverse lineages, including the spore-bearing bryophytes, lycophytes, and ferns, along with two lineages of seed plants within the gymnosperms, illustrated here (from left to right). Image credit: Emily Sessa. Image design: Jerald Pinson.

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