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OPINION

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Building an inclusive botany: The "radicle" dream

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Societal Impact Statement

It is important to recognize how our current understanding of plants has been shaped by diverse cultural contexts, as this underscores the importance of valuing and incorporating contributions from all knowledge systems in scientific pursuits. This approach emphasizes the ongoing bias, including within scientific practices, and the necessity of discussing problematic histories within spaces of learning. It is crucial to acknowledge and address biases, even within scientific endeavors. Doing so fosters a more inclusive and equitable scientific community. This article, while not comprehensive, serves as a starting point for conversation and an introduction to current work on these topics.

Summary

In response to a global dialog about systemic racism, ongoing inequalities, appeals to decolonize science, and the many recent calls for diversity, equity, accessibility, and inclusion, we draw on the narratives of plants to revisit the history of botany. Our goal is to uncover how exclusionary practices have functioned in the past and persist today. We also explore the numerous opportunities and challenges that arise in the era of information as we strive to establish a more inclusive field of botany. This approach recognizes and honors the contributions of historically marginalized groups, such as Black and Indigenous communities. We hope that this article can serve as a catalyst for raising awareness, fostering contemplation, and driving action toward a more equitable and just scientific community.

KEYWORDS
accessibility, botany, colonialism, history of science, participatory science, plant science, specimen digitization, traditional knowledge

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1 | INTRODUCTION

Knowledge of plants is age-old and undergirds most human cultures. On a global scale, however, the scientific study of plants, or *botany*, has been a fairly recent introduction, and one often associated with Europe and its colonies (Morton, 1981). As historians of botany have long noted, botany has had a fascinating, convoluted history linked to many other practices including medicine and agriculture, as well as natural history, but this past also includes forms of social injustice as well as exclusionary practices. A substantial body of literature underscores the wide array of cultural contexts in which knowledge of plants has been cultivated (Berlin et al., 1966, 1973; Raven et al., 1971). Yet, even with the recognition of plant knowledge originating from all corners of the world, contemporary botany remains predominantly Eurocentric (i.e., derived from European traditions). Therefore, here, we offer historical stories through the plants themselves, to highlight those individuals who dedicated their studies to botany but are not often discussed. Though we do not intend to encompass the whole of the history of botanical science or the human experience of the plant world, we do aim to capture something of the diversity of humanity that has contributed to the store of knowledge about plants.

Botanical collections serve as invaluable reservoirs of information; they are essential for scientific research, conservation, education, and providing a comprehensive resource for understanding plant diversity. Yet, accessibility to these collections has been severely limited. Historically, these collections were made all over the world, then transported to centers of learning and curation, located mostly in Europe. There, plants were turned into herbarium specimens (pressed and dried plants), stored, and labeled using standardized scientific methods. Hundreds of millions of botanical specimens are stored in the shelves, drawers, folders, files, and cabinets of herbaria, museums, and botanical gardens. These physical collections remain predominantly accessible only to individuals with specialized training, advanced degrees, institutional affiliations, and the resources required for extensive travel and research (Morton, 1981; Thiers, 2020). Access to these specimens has thus been severely restricted, despite the fact that these collections were often collected or informed by individuals who were marginalized, excluded, or prohibited from participating in the broader scientific community due to historical barriers based on race, gender, or other factors.

In addition to collections, the process of naming plants has played a crucial role in botany. It has enabled scientists to establish a shared name for a plant, making it possible for researchers to communicate, collaborate, connect, and share knowledge on a global scale. We acknowledge the significance of plant names and think that just as names give humans personhood, names also give plants planthood. The naming of plants is influenced by cultural perspectives, with scientific nomenclature being notably shaped by European and imperial contexts. While acknowledging that, throughout human history, plants have been named in diverse languages, dialects, and cultures (as noted by Foucault, 1970), there have been concerted efforts to harmonize local or Indigenous plant names and knowledge systems with standardized, scientific botanical practices. By embracing and acknowledging this vast reservoir of knowledge held within plant names, we can attain a richer and more holistic comprehension of the botanical world.

In this paper, we delve into the individuals who collected, studied, and named plants, shedding light on those who have often been excluded from historical accounts. By highlighting the contributions of these often marginalized individuals, we aim to recognize their invaluable role in shaping our knowledge of plants and enriching our understanding of the natural world. We discuss the challenges and barriers that many of these individuals faced as we attempt to ensure that their contributions are remembered. We aim to further the conversation by exploring the implications of the digital age, asking what our responsibility is in the context of information technology to avoid the perpetuation of harm and systems of exclusion. Our objective is to promote a more inclusive approach to the study of plants, recognizing the diverse voices and experiences that have shaped botanical knowledge.

2 | A HISTORICAL LEGACY HELD IN PLANTS

Here, we use plants as guides to share short stories that explore a plurality of narratives that include the contributions of historically marginalized people, including Black, Indigenous, people of color, queer people, women, and working-class collectors and researchers. We explore the effects of unequal access to scientific pursuits, show that common names can have a legacy beyond their origin, and reflect on how the study of plants has been inextricably linked to colonization and its legacies, along with other forms of exclusion, some distinct to each cultural context. Although the examples presented below predominantly center on the United States, similar examples may be found in other global contexts, and indeed, we argue that additional examples may emerge from closer historical study of the plants themselves. We encourage readers to think of plants as living objects that can tell stories themselves and to explore their histories in wider global contexts.

2.1 | Commemoratives showcase the contributions of women, Latine/x, Black, and Indigenous peoples

Commemoratives in botany involve naming plants after places or people, typically in recognition of their significant contributions to the field or their association with the plant's description or study. While most commemoratives are named for white men (see Mosyakin, 2022; Smith & Figueiredo, 2022; Smith et al., 2022; Guedes et al., 2023 and response by Antonelli et al., 2023), a more careful examination of the history of botany, one that questions the standard narrative and focuses on the narrative plants can tell, shows us that a diversity of people have contributed to the modern study of botany (Figure 1). We aim to highlight the significant contributions of Black and Indigenous communities, along with other marginalized groups, in the realm of natural history. We seek to add to the expanding body of literature, which still regrettably remains insufficient in recognizing these invaluable contributions (Das & Lowe, 2018;

FIGURE 1 A contemporary illustration of some of the plant scientists highlighted in this paper. In clockwise order from the 12 o'clock position: Elizabeth Knight Britton with *Eustichium norvegicum*, Ynes Enriquetta Julietta Mexía with *Mimosa mexiae*, Israel Lyons with *Plantago succisa* (synonymous with *P. lanceolata*), Marie Clark Taylor with *Salvia splendens*, Thomas Wyatt Turner with *Hordeum vulgare*, Sacagawea with *Lewisia sacajaweana*, Lafayette Frederick with *Cyrtandra frederickii* (synonymous with *C. dentata*), Catherine Furbish with *Pedicularis furbishae*, Hugo de Vries with *Oenothera grandiflora* (synonymous with *O. lamarckiana*), and Percy Gentle with *Clusia gentlei*. Importantly, at the top, we recognize the countless nameless contributors to the field. Artwork by Kasey Pham. CC BY-NC-SA.

Thiers, 2020; Bell & Caomhánach, 2020; Williams et al., 2021; Fletcher et al., 2021; #BLACKBOTANISTSWEEK 2020).

2.1.1 | *Pedicularis furbishae* S. Watson (Orobanchaceae; eudicot)

One of the reasons we see so few plants named in honor of women is perhaps best summarized by Maine botanist Catherine Furbish (1834–1931; Figure 1) when she learned that Harvard botanist, Sereno Watson, planned to name a plant to honor her. Furbish responded "…that were it not for the fact that I can find no plants named for a female botanist in your manual, I should object to '*Pedicularis furbishae*' for [having a plant named after who scientifically described it] is too often conferred to be any particular honor … But as a new species is rarely found in New England and few plants are named for women, it pleases me" (Vitiello, 2020). Furbish highlights the practice of naming species after men, as they were seen as the experts in the field. Women, who also contributed in many ways to botany, including collecting, documenting, describing, drawing, and preserving, were not typically considered equal authors of new scientific knowledge and therefore rarely recognized with commemoratives.

2.1.2 | *Quassia amara* L. (Simaroubaceae; eudicot)

Carl Linnaeus named this species to honor the controversial enslaved Ghanaian, Kwasimukamba, or Graman Quassi (other spellings: Quacy, Kwasi, and Quasi; 1692–1787). It is understood that Linnaeus named this plant to honor Quassi's medicinal applications, a rare acknowledgment by European scientists of the knowledge gained from Black and Indigenous people of the period. Quassi, an obeah/sorcerer, healer, and botanist, shared the plant's medicinal properties in treating intestinal parasites with the Dutch colonists, specifically Carl Dahlberg, an acquaintance of Linnaeus's at the time (Das & Lowe, 2018). Quassi gained much of his botanical knowledge through a relationship with the Maroon people of Suriname, mixed communities of Indigenous and escaped enslaved people. Quassi would go on to betray the Maroon communities by turning in runaway enslaved people who came to him for medical care; he also enabled colonizers to quell slave uprisings and guided the colonists through the forest (Das & Lowe, 2018). Quassi's story can provide us with a greater understanding of the complicated roles demanded of subordinated or colonized individuals. Figures like Quassi were not out of the norm within colonial regimes, and some regimes would not have functioned as they did without "go-betweens" or mid-level locals who served as intermediaries between the colonizers and colonized (Schaffer et al., 2009). Though many enslaved and colonized people would contribute to botanical knowledge of the period, few received any direct recognition, if they were mentioned at all. Quassi's participation in the system of Dutch enslavement and colonialism was key to his official acknowledgment. The story of Quassi emphasizes the idea that a single interpretation of history is insufficient and underscores the importance of revisiting and reevaluating historical narratives from various angles and perspectives. By doing so, we gain a more comprehensive and nuanced understanding of the complex forces, individuals, and circumstances that have shaped botanical science and its broader context.

2.1.3 | *Mimosa mexiae* Rose (Fabaceae; eudicot)

The contributions of Ynes Enriquetta Julietta Mexía (1870–1938; Figure 1), especially in plant exploration and botanical collections (Yount, 2007), have increasingly been recognized in recent years. Mexía is particularly notable given her unusual career path (Yount, 2007). She was one of the first Mexican-American women botanists and a prolific collector, working especially in regions of Latin America poorly studied by botanists. When Mexía developed physical and mental illnesses, her psychiatrist encouraged her to join the *Save the Redwoods League* and the Sierra Club, which helped her develop a deep interest in plants and nature. At age 51, Mexía enrolled at the University of California, Berkeley, where she was introduced to the study of botany. During her career, she collected more than 145,000 plant specimens, including 500 species she newly described.

2.1.4 | *Lewisia sacajaweana* B.L. Wilson & Rey-Vizg. (Montiaceae; eudicot)

While two of the most well-known explorers of the United States, Meriwether Lewis (1774–1809) and William Clark (1770–1838), are credited with documenting plants, animals, and geography in the newly acquired land from the Louisiana Purchase in 1803, these two explorers would likely not have been as successful without the tacit knowledge of the enslaved Sacagawea (or Sacajawea) of the Lemhi Shoshone (1788–1812 or 1884; Summitt, 2008; Figure 1) and a Black enslaved man, York (1770–75 - after 1815; Cayton, 2002). Neither Sacagawea nor York is listed as a collector on the specimens from the expedition, yet Lewis and Clark's journals revealed their essential role in the success of this expedition. Sacagawea introduced Lewis to western plants she collected for food, and York hunted to feed the crew. In 2005, researchers codified the connection between the Lewis and Clark Expedition and Sacagawea in naming this species (Wilson et al., 2005).

2.1.5 | *Clusia gentlei* Lundell (Clusiaceae; eudicot)

This plant was named to honor Percy Gentle (1892–1958; Figure 1), a Black Belizean who actively collected between 1931 and 1958. Gentle collected almost 10,000 specimens, including the type specimen for the species *C. gentlei* (Williams 2021; Meerman & Sabido, 2001). He is also credited with amassing the largest collection of Belizean plants (Adams & Cribb, 1985; Meerman & Sabido, 2001), of which there are more than 180 surviving wood specimens, although many more were lost in a hurricane in Belize in 1931 (Xylarium, University of Michigan, 2010. Many of Gentle's samples also include Mayan names or other ethnobotanical notes (Xylarium, University of Michigan, 2010), highlighting his acknowledgment of the relationship between Mayan people and local plants.

2.1.6 | *Cyrtandra frederickii* St. John & Storey (synonymous with *C. dentata* St. John & Storey; Gesneriaceae; eudicot)

Named for Howard University professor Lafayette Frederick (1923–2018; Figure 1), who served as the chair of the Botany Department (The History Makers, 2021), *C. frederickii* was likely named to honor Frederick's work on Hawaiian plants (St. John & Storey, 1950). However, Frederick is also recognized for racially integrating the *Association of Southeastern Biologists* annual meeting, which had not allowed its Black members to attend. For a long time, both the site and timing of scientific meetings were barriers to integration due to racial segregation laws and holding meetings during religious observances (Smocovitis, 2006).

2.2 | Disparities in scientific careers and participation

While some plants bear names that commemorate notable individuals, it is equally important to acknowledge those who left lasting impressions through their extensive studies and research on plant species, even if the plants themselves do not carry their names. Delving into the narratives of this next section of researchers unveils the disparities in paths toward scientific careers and barriers to scientific participation. The scientists highlighted below are individuals who, against all odds, overcame many of the obstacles placed before them. While progress has been made to reduce barriers to participating, both persistent and novel barriers still exclude people from scientific spaces.

2.2.1 | *Hordeum vulgare* L. (Poaceae; monocot)

Barley, beyond being an important agricultural crop, was also the focus of Thomas Wyatt Turner's (1877–1978; Figure 1) dissertation, entitled, "Studies of the mechanism of the physiological effects of certain mineral salts in altering the ratio of top growth to root growth in seed plants." Turner was not only the first Black American to receive a Ph.D. in botany, but he also helped to found the National Association for the Advancement of Colored People (NAACP). While Turner certainly had an impressive list of accomplishments, this did not prevent him from being denied access to a Botanical Society of America (BSA) annual meeting in 1931 (Smocovitis, 2006). Due to racial segregation laws, Turner was barred from entering the St. Charles Hotel in New Orleans, where the annual meeting was taking place (Smocovitis, 2006).

2.2.2 | *Eustichium norvegicum* Bruch & Schimp. (Synonymous with *Bryoxiphium norvegicum* Mitt.; Bryoxiphiaceae; Moss)

Scholars have shown that women have always been involved in botanical science, usually doing research not highlighted in the scientific literature, such as illustrating, compiling and analyzing data, and preparing herbarium specimens (Rossiter, 1982, 1998). These women—typically daughters, sisters, or wives of plant naturalists (Rudolph, 1982)—include Elizabeth Knight Britton (1858–1934; Figure 1), who was the first to describe and publish on the fruit of *E. norvegicum*, a species of moss (Knight, 1883). The privileges of social class and familial connections did not make Britton immune to exclusion due to gender. Britton was married to Nathaniel Britton, the New York Botanical Garden (NYBG) director and vice president of BSA. Yet Elizabeth Knight Britton and her women botanist friends were not permitted to attend the banquets at the early BSA annual meetings—even though she was one of the founding members (Smocovitis, *In prep*)!

2.2.3 | *Salvia splendens* Sellow ex Nees (Lamiaceae; eudicot)

While being white afforded Britton (above) access to certain spaces, other women such as Marie Clark Taylor (1911–1990; Figure 1), a Howard University professor and head of the Botany Department, had to overcome additional professional obstacles placed in her way because of race. Taylor was the first Black woman in the United States to earn a Ph.D. in botany and the first woman of any race to graduate with a Ph.D. from Fordham University, in 1941. Notably, she accomplished this a decade before the landmark Brown versus Board of Education decision (1954) and 23 years before the Civil Rights Act of 1964. For her thesis, she studied the effect of photoperiod on floral development in *S. splendens* and two species of *Cosmos*. Following the completion of her Ph.D., Taylor joined the Army Red Cross during World War II (Dinsmore, 2019). When she returned, she accepted a position at Howard University as an Assistant Professor. There she innovated the use of live plant material and light microscopes in classrooms, techniques still used today. These techniques were so successful that U.S. President Lyndon B. Johnson requested that she expand her work, introducing her teaching style to an international audience (Dinsmore, 2019).

2.2.4 | *Sphagnum* L. (Sphagnaceae; Moss)

Beyond gender and race, individuals who are disabled have also faced barriers in botany. Charles Léo Lesquereux (1806–1889) studied peat moss (once an important fuel) to understand its formation in peat bogs. Lesquereux suffered total hearing loss after a fall from a cliff in 1833 (Lang & Meath-Lang, 1995). After moving to the United States from Switzerland, Lesquereux drew on his expertise in peat bog formation to theorize the origin of coal formations. As a consultant for state geological surveys in several U.S. states, he performed pioneering investigations of Paleozoic floras. His study of the Carboniferous flora of Pennsylvania, entitled, "Atlas to the Coal Flora of Pennsylvania and the Carboniferous Formation throughout the United States," became a standard for U.S. Carboniferous floras (Lesley, 1890). In acknowledgment of his work, he became one of the first elected members of the U.S. National Academy of Sciences, although he never attended their meetings due to their inaccessibility for the hearing impaired (Lesley, 1890).

2.2.5 | *Plantago succisa* Lyons (synonymous with *P. lanceolata* L.; Plantaginaceae; eudicot)

Obstacles such as race and religion prevented botanists including Israel Lyons (1739–1775) (Figure 1) from accessing a university education. Lyons named the species *P. succisa*, but because he was Jewish, he was not allowed to attend the University of Cambridge and therefore could not academically participate in botany. While he later published a flora of Cambridge on his own, much of his work has sunk into obscurity, either due to the species he named being determined as synonyms, renamed due to updated taxonomy, or perhaps due to his status in society (Glyn, 2002).

2.2.6 | *Oenothera grandiflora* L'Hér (synonymous with *O. lamarckiana* Ser.; Onagraceae; eudicot)

Even in plant genetics, the "queer" phenomena displayed by plants like *O. grandiflora* were marginalized as aberrant forms of reproduction. Studied closely by Hugo de Vries (1848–1935; Figure 1), who identified himself as "queer" with a close group of co-workers (Campos, 2010), the plant briefly became the centerpiece of evolutionary study, when de Vries formulated his celebrated "mutation theory" based on the plant's ability to quickly develop changes to its genes that resulted in physical changes to the organism, or what he termed "mutations." Although the theory was enormously popular at the turn of the 20th century (Endersby, 2013), it found opposition from animal geneticists who favored the hypothesis of slow gradual evolution working on small individual differences. As a result, the plant's own distinct reproductive mechanisms, and de Vries's emphasis on understanding them, became marginalized to evolutionary workers. Nonetheless, de Vries's focused efforts in understanding complex reproduction in this plant inspired subsequent botanists and geneticists, who learned a great deal about chromosome behavior and grew to appreciate the complex evolutionary mechanisms seen in the plant world.

2.3 | Common names with derogatory meanings and a legacy beyond their origin

Many names today have a legacy of echoing discriminatory and racist stereotypes and tropes, reifying cultural norms suppressing marginalized people. This legacy is most visible in the language of common names. Common names, also known as vernacular names, are given to organisms by people in everyday language, often varying from region to region. While some of these common names may be immediately obvious in their harm, others require a deeper look at the historical context to recognize their problematic nature.

2.3.1 | *Tradescantia zebrina* Bosse (Commelinaceae; monocot)

Commonly referred to as "Wandering Jew" (as are the species *T. fluminensis* and *T. pallida*), this name comes from an antisemitic medieval myth where Jews were condemned to wander the land until the Second Coming of Jesus. This rhetoric has been used as propaganda against Jewish people and is still used to refer to people of the Jewish diaspora as outsiders or invaders. Especially in cases where alternative common names already exist, deliberate intent to use either the scientific name or alternative common names should be prioritized. For example, *T. zebrina* should be referred to as "inch plant" or "purple queen."

2.3.2 | *Dieffenbachia seguine* Schott (Araceae; monocot)

Other plants may have offensive common names that are not immediately apparent to their users. *Dieffenbachia*, a popular houseplant, for example, is commonly known as "dumbcane," which evokes ableist terminology. Plants in this genus have toxic properties, which can irritate the mouth and gastrointestinal tract when ingested. This irritation leads to loss of speech, or makes one "dumb." Due to this physiological effect, *Dieffenbachia* was often administered to enslaved people to prevent them from speaking, an especially cruel punishment (Barnes & Fox, 1955).

2.3.3 | *Ceratophyllum demersum* L. (Ceratophyllaceae; eudicot)

Some common plant names bear a close resemblance to derogatory terms and can unknowingly provoke discomfort and create an unwelcoming environment. The term "coon," a literal shortening of raccoon, was used as an anti-Black caricature, often associated with blackface minstrel shows that depicted Black people as animal-like, along with a host of other terms that were racial slurs. The common name of "coontail" for *C. demersum*, a common aquatic horticultural plant, is thought to derive directly from its leaf morphology resembling that of the tail of a raccoon. While not directly associated with any derogatory phrasing, its evocation nonetheless may conjure up racist stereotypes and slurs.

2.4 | The role of colonialism and the transatlantic slave trade

As European nations embarked on colonial expansion during the early modern era, their reliance on economically valuable plants became paramount for geopolitical expansion. The collection of plants with medicinal, edible, or utilitarian properties emerged as a central aspect of the plant trade. Collectors often enlisted enslaved people in these efforts; however, scientific and economic credit was not given to them by the collectors who exploited their labor, and at times, expertise.

2.4.1 | *Petiveria alliacea* L. (Petiveriaceae; eudicot)

Named for James Petiver (ca. 1665–1718; Murphy, 2023), an English apothecary, the species reveals the entwined connection between plant collecting and the transatlantic slave trade. Petiver relied on slave ship captains and surgeons who were charged with managing the health of enslaved Africans to maximize the success of slave voyages. The surgeons were ideal candidates among slaving crews as potential collectors of local flora as they were trained in botany, particularly plants with medicinal properties, and therefore were best suited to handling plant specimens (Murphy, 2023). Petiver knew that his collectors were dependent on enslaved Africans and Indigenous people for locating or collecting their specimens, even commenting that his collectors should be able to recruit any enslaved African to make a collection for them (Murphy, 2023). Unfortunately, standard practice at the time resulted in him never providing any credit to these individuals upon whose botanical knowledge and collection skills he relied.

2.4.2 | *Ipomoea batatas* Lam. (Convolvulaceae; eudicot)

The effects of the transatlantic slave trade can also be viewed through the names used for plants today. Van Andel et al. (2014) found that 2350 Afro-Surinamese plant names were correlated with common names used in western Africa for botanically related taxa. The authors concluded that when enslaved Africans were forcibly taken to the Americas, they recognized that substantial parts of the American flora were very similar to species in the African flora. This relationship between the names we use for plants today and the transatlantic slave trade has also resulted in the confusion we experience today in the grocery store over whether an orange tuber is a yam or a sweet potato. Yam, as currently used, refers to both the genus *Dioscorea* Plum. ex L. (Dioscoreaceae; monocot) and the species *I. batatas*. Since the word "yam" derives from several West African languages, translated as "to eat" or "sustenance," when enslaved West Africans arrived in the Americas without access to yam plants, they began using the same term for what is now known as the American yam, *I. batatas* (Carney & Rosomoff, 2009).

2.5 | The importance of Indigenous knowledge

Names given to plants by local Indigenous people typically highlight unique characters, habitats, or uses for that species, but this knowledge has been, and continues to be, typically lost when a scientific name is assigned to it (Gardner et al., 2022). This lost information is often exceedingly useful, and in many instances may prove to be crucial, especially in the Anthropocene when failure to include all available knowledge systems may only further the loss of biodiversity (Fernández-Llamazares et al., 2021; Gardner et al., 2022).

2.5.1 | *Pinus lambertiana* Douglas (Pinaceae; gymnosperm)

Sugar pine was likely given as a common name for this species of the Pacific Northwest of the United States due to its production of a resin used by Indigenous peoples as a sweetener (Lang, 2018; Lewis, 2018). David Douglas, who gave the plant its scientific name, wrote in his journal about both his observations of the plant and his interactions with the Indigenous tribe, the Umpquas, who lived closely with this plant. Journal entries describe the Umpquas setting fires to the plains to renew the land and produce more food. Only after a fire does the sap of sugar pine become chemically changed from bitter to sweet. Before the forced removal of tribal people by the U.S. government, several pine communities were managed by tribal groups who applied fire to reduce species competition (Kimmerer & Lake, 2001; Schenck & Gifford, 1952). When Douglas created a Latin name honoring Aylmer Bourke Lambert (a conifer expert), this connection to traditional ecological knowledge (TEK) was lost, leading to a serious failure to understand ecological phenomena, such as the risks associated with tree homogeneity and disruption of the age-class mosaic of trees across the North American landscape (Barrett, 2000).

2.5.2 | *Lophophora williamsii* J. M. Coult. (Cactaceae; eudicot)

Peyote, one of the few species of spineless cactus, is maybe more well known for its psychoactive properties when ingested. Peyote has been used by Indigenous peoples in traditional healing and religious practices for at least the last 5500 years (El-Seedi et al., 2005). However, due to racism and anti-Indigenous sentiment, peyote became the first drug ever outlawed in the Americas, banned by the Spanish Inquisition in 1620 (Dawson, 2017) and again in 1967 by the U.S. federal government (Stork & Schreffler, 2014). Perhaps not inconsequentially, the "War on Drugs" started gaining popularity around this time, acting as a legal pretext to disproportionately target, convict, and incarcerate people of color (Alexander, 2011). To protect their religious practices and use of peyote, Indigenous people created the Native American Church (Hernandez, 2014; Mosher & Akins, 2007). Through this formal and organized religion, the Native Americans' First Amendment rights and the use of peyote for religious ceremonies are protected (Mosher & Akins, 2007). John Coulter, despite the rich Indigenous cultural connection to this plant species, used the specific epithet "*williamsii*" in his scientific name, likely to honor the avid cactus collector Theodore Williams (1785–1875). This decision, though he was aware of the Indigenous use of the plant, overlooked the long-standing Indigenous knowledge associated with it (Van Heiden, 2020).

These stories are not a complete survey of the historical legacy held in the plant world but provide a pathway to explore the plurality of histories that challenge long dominant narratives of botanical science. As scholars explore the past, they also have begun to address the future of the field, as botany has become increasingly reliant on molecular and digital technologies. This historical shift poses new questions about inclusion, at the intersection of access, intellectual property and ownership, and participation.

3 | RESPONSIBILITY IN THE AGE OF INFORMATION

The Information Age, also known as the Computer Age, Digital Age, or New Media Age, began in the 1970s and continues to shape our world today. This period has facilitated a time in which individuals can readily obtain information and expand their knowledge. These technological advances afford us an unparalleled opportunity not only to explore the narratives of those who have made significant contributions to the field of botany but also to scrutinize the enduring legacies of colonialism and exclusionary practices. Through increased awareness, rigorous examination, and productive discourse, we can strive to not only comprehend these legacies but also to devise novel methods and establish policies that can potentially reduce, if not entirely eradicate, their impact. In the subsequent section, we transition our discussion from the past to the present and future, exploring how emerging information technology can potentially contribute to a more inclusive botanical science. Despite the promise of these technological advancements, it remains essential to consider thought-provoking questions posed by media scholars like Wendy Hui Kyong Chun, who inquire whether we are genuinely progressing or merely "updating but remaining the same" (Chun, 2017).

3.1 | Insights from digitizing biodiversity collections

The ability to highlight individuals such as those described above is in part due to several initiatives to digitize biodiversity collections and the information stored within them. Digitization of archival and herbaria collections offers a potentially more democratic approach to providing access within and outside the field (e.g., Drew et al., 2017; James et al., 2018; Nelson & Ellis, 2018; Page et al., 2015). Increasing data accessibility holds promise in encouraging people from all backgrounds to explore and create new meaning from these data. Large efforts such as Integrated Digitized Biocollections (iDigBio; www.idigbio.org) and the Global Biodiversity Information Facility (GBIF; www.gbif.org) increase access to not only a digital version of the specimen itself but also the information associated with the specimen such as when and where the specimen was collected and the name(s) of the collector(s). This information can then be further processed through databases such as Bionomia (https://bionomia.net), which aims to link natural history specimens to their collectors. To inspect who these collectors are, we queried all specimens associated with the Kingdom Plantae in iDigBio. After manual editing due to inconsistency of input (see Methods S1), we found that collector names on specimens only tell part of the story. When we examine the names listed in the collector field, a discernible trend emerges: there is a growing count of named contributors over time, accompanied by a

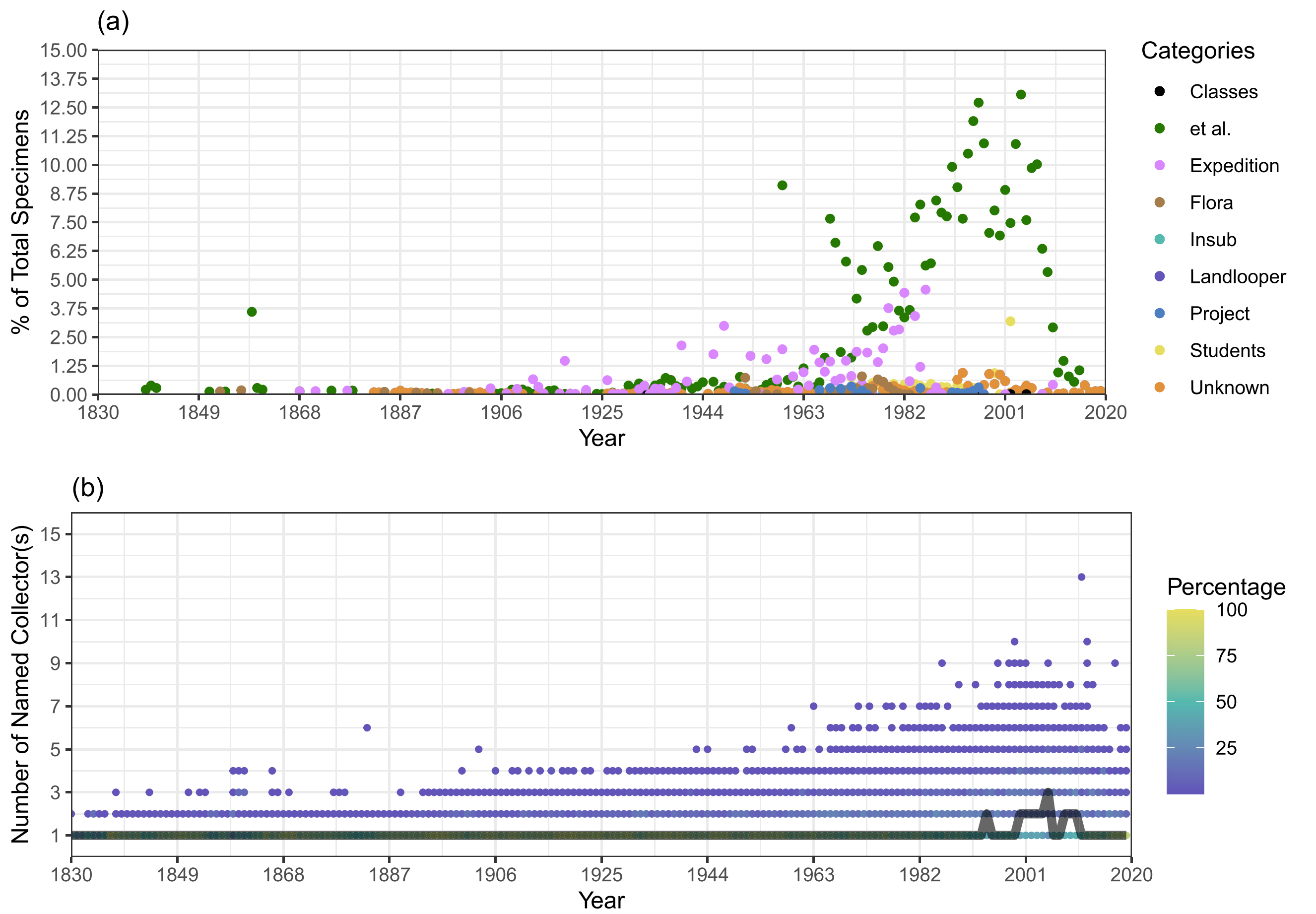

FIGURE 2 The number of collectors given on each specimen label from 1830 to 2020 for all plant specimens downloaded from iDigBio on June 28, 2020. (a) Percentage of the total specimens with ambiguous categories (Insub is an abbreviation used to refer to insubordinate). (b) the number of non-ambiguous named collectors per specimen is summarized based on the percentage of total specimens with a specific number of named collectors per year. The black line indicates the median number of collectors per year. See Methods S1 for additional details.

rising level of ambiguity (Figure 2), meaning that groups of people (e.g., students, classes, or those affiliated with specific projects, floras, or expeditions) have often been amalgamated into collective attributions (Figure 2a). Consequently, this practice obscures the individual identities of these contributors, denying them the recognition they would receive if credited individually. In some instances, specific student groups have been referred to on herbarium specimens; for example, "landloopers" refers to students of Valckenier Suringar in the Netherlands (Breteler & Sosef, 1996). The use of "et al." is possibly an artifact of databasing practice rather than the actual use of ambiguous notation; however, using this notation prevents those collectors' names from being findable and added to databases like Bionomia. Recently, Dikow et al. (2023) used records from GBIF and Smithsonian annual reports to identify the scientific contributions of 40 women who previously worked at the Smithsonian, thereby offering a more comprehensive understanding of the individuals involved in their collection efforts. Without the digitization of collections, patterns such as these cannot be identified, much less interrogated.

While on the surface, digitizing specimens and the information stored within them increases accessibility, enabling more people to work and learn from these data, digitization also allows label data with sensitive information to be shared more widely. Sometimes, this sensitive (or sometimes offensive) information may be obvious, and institutions may choose to mask the information, only sharing it upon request or providing pop-up warnings to users prior to accessing the database (Briscoe et al., 2022). However, in scenarios where the information was included without permission, researchers may not realize it is sensitive, and because of a lack of inclusion from marginalized botanists, this information goes unprotected. One such example is when First Nations and Indigenous peoples' sacred cultural practices are shared without permission.

3.2 | Traditional knowledge acknowledgment

While the promise of information technology enables increased access to a broader range of people, it also comes with a greater potential for misattribution. Initiatives such as biocultural Labels (https://localcontexts.org/) are one way to both manage misattribution and provide an opportunity for open dialog with Indigenous peoples on the future use of information, biological collections, and data that derive from their associated lands, waters, and territories. Biocultural labels (an extension of traditional knowledge labels) are digital tags that can specifically be used to address issues of ownership, access, and control regarding Indigenous knowledge related to biology. These types of initiatives that encourage dialog while also legally protecting rights are especially promising for creating a more equitable botany.

3.3 | Expanding plant authorship

Other databases such as the International Plant Names Index (IPNI)—a database of plant and author names—allow for authorship to be tracked. A complete scientific name includes the genus name, specific epithet, and author (e.g., *Cephalotaxus koreana* Nakai). Nakai, at the end of the species name, refers to Takenoshin Nakai (1882–1952), a Japanese botanist who studied plants of Japan and Korea and is credited with naming over 3000 plants (www.ipni.org/a/23869-1; accessed: November 4, 2021). While databases like IPNI and Bionomia represent excellent steps in recognizing effort and contribution, confusion around correctly associating the published name with the actual person and the precise citation of the author persists, especially for those with non-anglicized names (Ghahremaninejad et al., 2015; Deng et al., 2017; Vallejos, 2021). Efforts to disambiguate authors include using unique identifiers such as ORCIDs for which researchers can register (Haak et al., 2012; https://orcid.org). While building these databases offers the promise of wider historical recognition, it may inadvertently replicate the ongoing omission of people and knowledge. How we think about "authorship" broadly should be assessed; for example, in some cases, the knowledge of a group is appropriated and becomes associated with just one person, often a person not part of that group. No matter how successful we are at digitizing and disambiguating data, the names that were never recorded may never be known.

3.4 | Revisions and equity in botanical nomenclature

Based on the International Code of Nomenclature (ICN) for Algae, Fungi, and Plants, there must be only one scientific name used to refer to a particular species. These scientific names must be validly published by following the articles of the ICN and be legitimate. When two names are assigned to the same species, the accepted or legitimate scientific name is determined by the principle of priority, meaning the name that was first published takes precedence. The names that are considered valid, but published later, then become synonyms. However, names can bear a history that can be forgotten when relegated to synonyms. For example, *C. frederickii*, mentioned above as a commemorative for Lafayette Frederick, is now considered a synonym of the accepted name, *C. dentata*, in reference to the plant's leaf morphology. Such revisions that designate the commemorative as a synonym result in limiting its usage and, unfortunately, in this case, obscuring the more widespread recognition of Frederick's work. Despite the rules outlined in the Code, there are times when names rise to be considered a "specified case," when the correct scientific names do not catch on and alternative names have been broadly accepted (e.g., *Galax*; Brummitt, 1972). Currently, there are live proposals for changing the Code to allow for re-naming of species (Gillman & Wright, 2020; Knapp et al., 2020; Smith & Figueiredo, 2022; Thiele et al., 2022; Wright & Gillman, 2021). However, these proposals can only be accepted at the International Botanical Congress, a meeting that typically occurs every 6 years.

Included in these proposals is the suggestion of consciously assigning and reinstating Indigenous names for species, whenever feasible (Gillman & Wright, 2020; Knapp et al., 2020; Wright & Gillman, 2021). Fundamental to this proposal is the principle of priority, as the existing taxonomic codes do not recognize the chronological precedence of most, if not all, Indigenous names, which frequently convey comprehensive knowledge about plants (Gillman & Wright, 2020). Establishing a mechanism through which Indigenous communities can propose name changes is likely to yield positive outcomes for both biodiversity conservation and the enhanced engagement of Indigenous peoples (Kimbrough, 2021; Wilder et al., 2016; Wright & Gillman, 2021). Additionally, by including and learning more about Indigenous names, we may develop a more expansive and inclusive understanding of biodiversity (Gardner et al., 2022).

Other reasons for providing a path to name changes involve taxa with offensive scientific names (Smith & Figueiredo, 2022; Thiele et al., 2022). While above we discuss taxa with offensive common names, plants with problematic scientific names also exist. One example is the specific epithet "*caffra*", which is derived from an extremely offensive word for Black Africans. According to IPNI (accessed: November 8, 2021), more than 130 species carry this epithet. While there are existing pathways for changing offensive names, a more proactive stance, in which these names are rejected and replaced by new names, would be productive for a more equitable botany. This is well outlined by Knapp et al. (2020) in their best practices for nomenclature.

3.5 | Ownership and access in the digital age

Historically, many natural history collections were regarded as the property of wealthy individuals. When these wealthy individuals died, many of their collections were then purchased by or donated to institutions or nations, which then took over responsibility for maintaining the vast collections, typically increasing them in volume. We are again moving toward a new cultural shift and idea of ownership with the development of open access—freely available on the internet—digitized collections. It is notable that actual repatriations, the return of botanical specimens to the countries where they were originally collected—whether possible or not—is rarely discussed or mentioned by institutions reckoning with their collections' pasts (dos Santos, 2016). Therefore, some efforts, such as REFLORA, use a virtual herbarium to connect images and information concerning Brazilian plants deposited overseas as a sort of digital repatriation effort (Forzza et al., 2016). However, the equity of open access has been questioned, especially as it relates to Indigenous data sovereignty (e.g., Carroll et al., 2021; McCartney et al., 2022). While more frequently discussed in terms of genomic data, digital collections also contain specimens that were collected without consent and are typically not properly attributed as coming from Indigenous lands. Therefore, we must ask: who is benefiting from open access?

3.6 | Participatory science and the decentralization of botanical knowledge

Perhaps one of the largest efforts to decentralize ownership in botany is the advancement in participatory science, where the public contributes to scientific knowledge and understanding. With personal computers and smartphones, a whole new world has been created in which the global community can participate in documenting biodiversity. Applications like iNaturalist (https://www.inaturalist.org/) allow anyone with access to the internet and a camera the chance to document the life around them. The success in integrating community members in botany is demonstrated through publications, such as the documentation via an iNaturalist observation of *Isoëtes viridimontana* (Rosenthal et al., 2014; www.inaturalist.org/observations/384993). The community member whose observations were critical for the scientific description of *I. viridimontana* was then included as a co-author on the resulting publication (Uyeda et al., 2020), extending who can participate in the publication process. By including local communities in science, along with their knowledge and traditions, we can expand the thought and culture in science (Nordling, 2018).

3.7 | A global movement

Globally, most countries have taken steps to attempt to promote equity in biodiversity research. One such effort, the Nagoya Protocol on Access and Benefit Sharing (https://www.cbd.int/abs; https://learnnagoya.com), covers the use of genetic resources and traditional knowledge associated with those genetic resources. By ratifying this protocol, participating countries (the list of which does not include the United States) agree to the fair and equitable sharing of benefits arising from the use of biological diversity data. The resulting framework is designed to prevent exploitation and ensure that Indigenous and local communities receive benefits through a legal process that respects the value of traditional knowledge associated with future genetic resources, while also conserving biodiversity. Recent work by Marks et al. (2021) highlights the importance of these types of global agreements. The authors map the geographic distribution of the submitting institutions for almost 800 plant genome assemblies to demonstrate that the field has been dominated by what we now consider the Global North, despite a wide geographic distribution of study species. This approach of collecting plants in foreign countries without engaging, acknowledging, or collaborating with local researchers is often referred to as "parachute science," which Marks et al. (2021) argued is rooted in historical and ongoing colonialism. Along with international agreements like the Nagoya Protocol, the authors suggest—and we agree—that as a community, we need to work together to ensure that ethical approaches are taken so that in-country peoples are given a voice, participation, access to resources and data, and sovereignty at every level (Marks et al., 2023; McCartney et al., 2022).

3.8 | Using technology for accessibility

Disability represents a form of diversity with accessibility remaining an ongoing issue toward greater inclusivity. The Americans with Disabilities Act (ADA), passed in 1990, and ensuing similar legislation around the world, such as the Equality Act 2010 in the United Kingdom, the Accessibility for Ontarians with Disabilities Act (AODA) in Canada, the Disability Discrimination Act 1992 in Australia, and the European Accessibility Act (EAA) in the European Union, have drawn greater attention to the challenges of living within an ableist society. In the United States, newly constructed botanical spaces have increased physical accessibility through building modifications; however, cost continues to be the biggest obstacle to greater inclusion in older facilities (Wysocki, 2018). Museums have also added technologies to provide access to people with visual and hearing impairments. Exhibits can be modified to be viewed with touch through 3D printing, and museum audio can be amplified with Assisted Listening Devices (Nolan, 2016). Innovative technologies have been implemented to help people with sensory impairments and learning disabilities access museums as well, including multisensory artwork and augmented reality applications (Garcia Carrizosa et al., 2020). Yet, the research and collections side (usually not accessible to the public) largely lags in creating inclusive, all-accessible spaces (Brown & Leigh, 2018, 2020).

Many times, researchers working with plant collections need to perform repetitive motions. Tools such as voice-to-text software, automatic paper cutters, and other assistive technologies can facilitate access for those who are neurodiverse or have mobility issues. Yet, costs are often prohibitive in creating more equitable access to scientific research. Emerging technologies, such as robotic collection management systems (Hardy et al., 2020), could also help to decrease mobility requirements, allowing collection managers to focus on species identification rather than physically acquiring and returning (i.e., filing) specimens, which could open the collection doors to disabled scientists. Disabilities can also limit a scientist's access to nature and ability to participate in fieldwork (Demery & Pipkin, 2021). In 2015, the U.S. National Park Service committed to increasing accessibility across all services (National Park Service, 2014). Despite these improvements, moving off-trail is still difficult, and thus, additional calls for action to find inclusive fieldwork practices and create assistive technologies have begun (Chiarella & Vurro, 2020).

In the current age of information and technology, novel and unexpected barriers are forming. It is imperative that we approach the digitization processes critically to avoid replicating the inequities found in natural history collections (Kaiser et al., 2023). We should adopt a broad perspective to consider how the format, timing, and locations of our events may unintentionally exclude individuals from participating and having their voices heard in shaping standards, fostering collaborations, and accessing opportunities. Additional efforts and funding are needed to incorporate available technologies into botany; for example, adding alt-text on manuscript figures would enable visually impaired researchers to access the information they could not before.

4 | THE “RADICLE” DREAM FOR BOTANY

From its inception to the present day, the scope of botanical science continues to evolve, expanding from a focus on medicinal and agricultural aspects to now encompassing natural history and biodiversity. The endeavor for inclusivity not only seeks to elevate the caliber of scientific research by embracing diverse perspectives but also to challenge the current confines of botanical scientific inquiry. However, promoting equity, both within and outside the academic community, is an ongoing endeavor that demands persistent advocacy and concerted efforts. In the realm of botanical science, this journey starts with a crucial recognition of the societal structural and cultural biases that have historically marginalized individuals based on their race, gender, and LGBTQ+ identities.

Natural history collections play a pivotal role in documenting the narratives of individuals who have historically been underrepresented in early botanical research, revealing their contributions to our contemporary understanding of botany. While it is possible to unearth the narratives of some marginalized individuals, offering a glimpse into the diverse array of people who have enriched our collective botanical knowledge, it is crucial to emphasize that mere acknowledgment falls short of achieving true equity. Regrettably, the underrepresentation of specific groups persists (refer to National Center for Science and Engineering Statistics, 2023).

Individuals who stand as symbols of this inclusivity may not always receive the necessary support to voice their concerns regarding issues like racism, sexism, or institutional abuse. In some unfortunate instances, they may encounter repercussions, including silencing or even removal, when challenging the authority figures perpetuating these problems. A *radical* overhaul of the existing systems of exclusion that exist today necessitates a deliberate and mindful commitment to inclusivity that spans gender, race, religion, ability, class, and sexual orientation, while also acknowledging the complexities of intersectionality. This paper has strived to confront the challenging historical aspects of botanical research, investigating the *roots* of the field and pondering our responsibilities in the age of information technology. Nonetheless, it is essential to note that the perspectives expressed herein are shaped by the authors' viewpoints, personal experiences, and biases.

Our aspiration is that this paper will broaden the discourse, inspiring individuals with diverse backgrounds and experiences to engage with the issues introduced here, explore the extensive body of literature, and contribute to fostering a more inclusive botany. Ultimately, our shared objective is to create a botanical community that is not only enriched by a deeper understanding of plants but also welcoming to the richness of human diversity.

AUTHOR CONTRIBUTIONS

Makenzie E. Mabry, Nuala Caomhanach, R. Shawn Abrahams, Michelle L. Gaynor, Kasey Khanh Pham, and Tanisha M. Williams worked together to write an original draft of the manuscript. All co-authors researched plants tied to important themes, identified botanists to highlight, and participated in discussions on responsibility in the age of technology. Kathleen S. Murphy, Vassiliki Betty Smocovitis, Douglas E. Soltis, and Pamela S. Soltis provided feedback and edits and added additional plant examples and historical context where necessary. All authors contributed to the writing and proofing of the final version.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

We hope our paper can be a valuable tool for introducing students to alternative perspectives in botany. To help with this goal, we have published an associated open education resource (OER) on Qubes (https://qubeshub.org/publications/4443/2; doi: 10.25334/SQSN-QQ64), which includes discussion questions and an instructor guide that enables ongoing conversations. We also hope to encourage more work on the topics at hand and to point to the abundant literature that provides us with a richer, kinder, and just understanding of the plant world on a global scale; and we acknowledge that our own experiences—and identities—both enable and restrict our project.

Scripts and data files can be found at https://doi.org/10.5281/zenodo.7595168.

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