Building an Inclusive Botany: The "*Radicle*" Dream

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SUMMARY

Driven by the national conversation on systemic racism, ongoing inequities, appeals to decolonize science, and the many recent calls for diversity, equity, accessibility, and inclusion, we use stories of plants to discuss the history of bias and exclusionary practices in scientific botany, particularly regarding access to scientific spaces, and the exploitation of marginalized peoples. We discuss the many opportunities and challenges presented by the age of information technology as we seek to create a more inclusive botany that recognizes and acknowledges the contributions of historically marginalized groups, including Black and Indigenous communities. We hope this article can be used as a conversation starter to raise awareness, encourage reflection, and promote action toward creating a more equitable and just scientific practice.

KEYWORDS

Accessibility, Botany, Colonialism, Community Science, History of Science, Plant Science, Specimen Digitization, Traditional knowledge

SOCIETAL IMPACT STATEMENT

By recognizing the diversity of cultural contexts that have shaped our understanding of plants, we emphasize the importance of valuing and incorporating the contributions of all knowledge systems in scientific pursuits. We highlight ongoing bias in scientific practice, including our own, and the necessity of discussing problematic histories in spaces of learning. This article is not meant to be a comprehensive review but instead serves as a starting point for conversation and an introduction to current scientific work on these topics.

INTRODUCTION

Although scientists strive towards an objective understanding of the natural world, the history, philosophy, and sociology of science have shown that true objectivity continues to elude us (Kuhn 1962; Daston and Galison 2021). Driven by humans with their own individual perspectives influenced by larger societal frameworks, bias is an inherent property of scientific practice. Despite best efforts to examine the past in critical terms and a long history of trying to right the many past wrongs, the scientific community continues to marginalize individuals and indeed entire collectives of people who have contributed and continue to contribute to our store of existing knowledge. How can we recognize this bias we all hold and design a set of critical tools that will enable us to think outside ourselves, or even our cultures? Motivated by the national conversation on systemic racism, growing disparities and inequities, the many recent calls for diversity, equity, accessibility, and inclusion, and appeals to decolonize science (Nordling 2018; Roy 2018; McAlvay et al. 2021; Marks et al. 2023), we turned to these long-standing concerns from the perspective of botanical practice. This paper aims to serve as a bridge to assist educators and students in the classroom to discuss the complex histories of imperialism, racism, colonialism, and oppression that cast a long shadow over the field. We ask, "What could botany look like if the historical practices associated with colonialism were acknowledged and a new emphasis on inclusion were adopted"?

First, we recognize that knowledge of plants is age-old and undergirds most human cultures. Against this global backdrop, the scientific study of plants, what we call *botany*, has only been a recent introduction and one tied mostly to western culture (Morton 1981). Although it has had a fascinating, convoluted history drawing on many other scientific developments, we know that it cannot be divorced from exclusionary practices. For example, like all other natural history collections, herbarium specimens (pressed and dried plants) are stored and labeled using standardized methods developed over centuries. Until the last few decades, these millions of botanical specimens worldwide have been kept in shelves, drawers, folders, files, and cabinets of museums and botanical gardens and were essentially only accessible to individuals with higher degrees, institutional affiliations, and sufficient wealth to travel to those institutions that house the collections. Access to these specimens, and thereby scientific practice, was indirectly or directly limited to white people of an upper class or higher socioeconomic status, despite the fact that marginalized peoples had played critical roles in collecting and identifying them.

Just as names give humans personhood, names also give plants planthood. The attribution of names to plants is heavily influenced by the cultural context in which they are given, and scientific naming, in particular, has predominantly been shaped by Western culture. Nevertheless, throughout history, plants have been named in various languages, dialects, and cultures (Foucault 1970). A substantial body of literature exists wherein researchers strive to reconcile local and Indigenous knowledge with the Western scientific tradition. This literature, exemplified by the works of Berlin et al. (1966, 1973) and Raven et al. (1971), emphasizes the importance of recognizing the diverse cultural contexts through which knowledge of plants has been acquired. Despite these efforts, achieving equitable representation and inclusion of these systems in the field of botany remains a challenge. How can we actively work towards a more inclusive botany that embraces and integrates a broader range of cultural perspectives?

With all of this in mind, we critically reevaluate and push against the existing paradigms of the history of scientific botany, by offering stories of plants and individuals that depict the diversity of ways that humans have gained knowledge of the plant world. Following a historical view, we look ahead to newer practices drawing on information technologies. Briefly stated, we do the following:

1. Explore plants that illuminate stories of botanists typically excluded from traditional narratives. While recent work, especially on the important role that Black and Indigenous communities have played in science, has gained visibility, it remains comparatively scarce; we wish to add to and amplify this growing literature (Das and Lowe 2018; Thiers 2020; Bell and Caomhánach 2020; Williams et al. 2021a; Fletcher et al. 2021; #BLACKBOTANISTSWEEK 2020).
2. Consider what it means to reckon with botany's complex past and move forward to create a more inclusive space, one that enables full participation by all. We offer possibilities for rethinking language and naming, especially when it potentially alienates, excludes, or diminishes the contributions of people or when it bears the legacies of colonialism.
3. We ask what our responsibility is in the age of information technology, in which botanical science is immersed, to avoid perpetuating harm or supporting systems of racism and colonialism.

In practice, this article is intended to be a tool for introducing students, especially undergraduates, to the work actively being done within the scientific space on the topics noted above, and for engaging them in work still to be done. To help with this goal, we have published an associated open education resource (OER) on Qubes (*link will be added after paper acceptance*) which includes discussion questions and an instructor guide to help facilitate these important conversations. We acknowledge that this paper is not a comprehensive review of the subjects addressed, but rather a starting point for a deeper dive into the literature. Further, in line with the ethos put forth here, the topics covered and views expressed reflect the positionalities, experiences, and biases of the authors.

A HISTORICAL LEGACY HELD IN PLANTS

A history of botany told through the lens of plants themselves, through plant stories or vignettes, offers us one pathway to critically interrogate the history of botanical science. Here, we use plants to discuss the contributions of marginalized people, including Black, Indigenous, people of color, queer people, women, and working-class collectors, to the history of botany. We explore the effects of unequal access to academia and scientific knowledge, learn that common names can have a legacy beyond their origin, and reflect on how the study of plants has relied on the exploitations of the transatlantic slave trade and the appropriation of Indigenous expertise.

Honorifics Showcase the Contributions of Women, Latine/x, Black, and Indigenous People - Although it is true that most honorifics – plants named after someone – are named for white men (see Mosyakin 2022, Smith and Figueiredo 2022, Smith et al. 2022, Guedes et al. 2023 and response by Antonelli et al. 2023), a closer look reveals that many diverse people have contributed to the study of botany (**Figure 1**).

Figure 1. A contemporary illustration of some of the researchers 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 (*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 glazioviana* (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.

Pedicularis furbishae (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) 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 its discoverer] 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 honorifics.

Mimosa mexiae (Fabaceae; Eudicot) - The contributions of Ynes Enriquetta Julietta Mexía (1870 - 1938), 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 western 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 new to western science, of which several are named in her honor.

Lewisia sacajaweana (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 Lemhi Shoshone (1788 - 1812 or 1884; Summitt 2008) 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's 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), yet there are no honorifics for York or any of the other members of the Corps of Discovery Crew (although they were compensated financially, unlike York or Sacagawea) to acknowledge or honor their contributions and legacy.

Clusia gentlei (Clusiaceae; Eudicot) - This plant was named to honor Percy Gentle (1892 - 1958), 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 2021b; Meerman and Sabido 2001). He is also credited with amassing the largest collection of Belizean plants (Adams and Cribb 1985; Meerman and 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). Many of Gentle's samples also include Mayan names or other ethnobotanical notes (Xylarium, University of Michigan), potentially highlighting his acknowledgment of the relationship between Mayan people and local plants.

Cyrtandra frederickii (synonymous with *C. dentata*; Gesneriaceae; Eudicot) - Named for Howard University professor Dr. Lafayette Frederick (1923 - 2018), 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 and 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).

Unequal Access to Scientific Spaces - Scientific meetings play a crucial role in professional development for botanists as they provide opportunities to establish collaborations, develop new ideas and strategies to approach research questions, and get inspired. However, due to gender, race, ability, and religion, people have been excluded from attending scientific meetings and institutions. The scientists highlighted below are individuals who, against all odds, overcame many of the obstacles placed before them. We must, however, be mindful of the fact that the record does not list the names of individuals who were turned away and prevented from participating in botany. While progress has been made to reduce barriers to participating, both persistent and novel barriers still exclude people from scientific spaces.

Hordeum vulgare (Poaceae; Monocot) - Barley, beyond being an important agricultural crop, was also the focus of Dr. Thomas Wyatt Turner's (1877 – 1978) dissertation thesis, 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 NAACP (National Association for the Advancement of Colored People). While Turner certainly has 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).

Eustichium norvegicum (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, computing 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), who was the first to describe and publish on *E. norvegicum*, a species of moss (Knight 1883). Even a woman of such status, as she was married to Nathaniel Britton, the New York Botanical Garden (NYBG) director and Vice President of BSA, was not immune to exclusion due to gender. 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*)!

Salvia splendens (Lamiaceae; Eudicot) - While being white afforded Britton access to spaces, other women such as Dr. Marie Clark Taylor (1911-1990), a Howard University professor and head of the Botany Department, had to overcome additional obstacles to gain access to perform research due to her race. Taylor was the first Black woman in the U.S. 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. 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).

Sphagnum (Sphagnaceae; Moss) - Beyond gender and race, individuals who are disabled have also faced barriers in botany. Charles Léo Lesquereux (1806 – 1889) studied peat moss for the role of its formation in peat bogs, which at one time was an important fuel. Lesquereux suffered total hearing loss after a fall from a cliff in 1833 (Lang and 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).

Plantago succisa (synonymous with *P. lanceolata*; Plantaginaceae; Eudicot) - Obstacles such as race and religion prevented botanists including Israel Lyons (1739 - 1775) 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).

Oenothera glazioviana (synonymous with *O. lamarckiana*; Onagraceae; Eudicot) - Even in plant genetics, the “queer” phenomena displayed by plants like *O. glazioviana* were marginalized as aberrant forms of reproduction. Studied closely by Hugo de Vries (1848-1935), 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 century (Endersby 2013), it found opposition from animal geneticists who favored the hypothesis of slow gradual evolution working on small individual differences. In the process, 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.

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. 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.

Tradescantia zebrina (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 used. For example, *T. zebrina* should be referred to as 'inch plant' or 'purple queen.'

Dieffenbachia seguine (Araceae; Monocot) - Other plants may have offensive common names which 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 and Fox 1955).

Ceratophyllum demersum (Ceratophyllaceae; Eudicot) - Other 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.

The Role of the Transatlantic Slave Trade - As European nations began to build empires in the early modern period, plants of economic value were crucial for geopolitical expansion. Collecting medicinal and edible plants was a significant focus in 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.

Petiveria alliacea (Petiveriaceae; Eudicot) - Named for James Petiver (ca. 1665–1718; Murphy 2013), 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 better suited to handling plant specimens (Murphy 2013). 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 2013). 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.

Ipomoea batatas (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 2,350 Afro-Surinamese plant names were correlated with common names used in western Africa for botanically related taxa. The authors concluded that enslaved Africans recognized substantial parts of the American flora when they were forcibly taken there. 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* (Dioscoreaceae; Monocot) and the species *Ipomoea 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 the American yam, *I. batatas* (Carney and Rosomoff 2009).

The Influence of Indigenous Knowledge - Despite the European taxonomic system appropriating Indigenous knowledge yet omitting attribution, common names of plants reveal the influence of Indigenous use and knowledge. Names given to plants by local people typically highlight unique characters, habitats, or uses for that species, but this knowledge is then typically lost when a scientific name is assigned by someone outside of that community (Gardner et al. 2022). Especially in this age of climate change and threats to biodiversity, the failure to include other knowledge systems in our decision processes will only further exacerbate the loss of biodiversity (Fernández-Llamazares et al. 2021; Gardner et al. 2022).

Pinus lambertiana (Pinaceae; Gymnosperm) - Sugar pine was likely given as a common name for this species 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 U.S. federal forced removal of tribal people, several pine communities were managed by tribal groups who applied fire to reduce species competition (Schenck and Gifford 1952; Kimmerer and Lake 2001). This relationship between the sugar pine and the Umpquas is highlighted in the Umpquas’ name for the tree, *Nat-cleh*, which Douglas notes; yet despite the obvious cultural use of the tree, he created a Latin name for the tree based on a scholar in Britain (Aylmer Bourke Lambert, a conifer expert). Knowing that Douglas was aware that the tree had a name, yet disregarded it, is just part of an incredibly common practice in the history of exploration and colonization. This loss of connection between name and traditional ecological knowledge (TEK) has resulted in tree homogeneity, increased disease, and disruption of the age-class mosaic of trees across the North American landscape (Barrett 2000).

Lophophora williamsii (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 5,500 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 and 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 (Mosher and Akins 2007; Hernandez 2014). Through this formal and organized religion, the Native Americans' First Amendment rights and the use of peyote for religious ceremonies are protected (Mosher and Akins 2007). Despite this rich history and connection to Indigenous culture, when John Merle Coulter gave this species a scientific name, he used the specific epithet "*williamsii*". While in his original description, he does not explicitly state for whom this plant was named, he does state, "Mrs. A.B. Nickles [An American cactus collector] reports that Indians use the plants in manufacturing an intoxicating drink, also for 'breaking fevers,' and that the tops cut off and dried are called 'mescal buttons'" (United States National Herbarium 1894). The "Williams" in question most likely is for the avid cactus collector Theodore Williams (1785 —1875), rather than a name to honor the Indigenous knowledge of the plant (Van Heiden 2020).

RESPONSIBILITY IN THE AGE OF INFORMATION TECHNOLOGY

Due to the nature of colonialism, we will never know the names of many of those marginlized people who helped build botanical science, especially those who resisted the power structures of the time. Those who participated actively in the systems of colonialism and enslavement, such as the controversial Graman Quassi of Suriname, were more likely to be recognized for their contributions. Quassi, perhaps the first Black man to receive an honorific, was known for turning in escaped enslaved people who came to him for medical care and working to quell slave uprisings (Das and Lowe 2018). Though we may consider his actions terrible today, per the "system-justification" theory of social psychology (Jost and Banaji 1994; Jost et al. 2004), it is an average or usual choice for a person to support and participate in a system that oppresses them. When we consider why Quassi's expertise was recognized while others were not, it is impossible to disentangle colonialism and enslavement's role in shaping who could be seen as a botanist.

We cannot assume that a system is just or inclusive today merely by the participation of marginalized people. Representation alone in the field does not provide evidence of an inclusive community of researchers, as representation can be a form of institutional capital where these individuals are used to signal that a community is a welcoming space. Those same people may not be supported in voicing their concerns over acts of racism, sexism, institutional abuse, etc. and will be silenced when pushing back against those barriers. As members of a scientific community, we must actively and consciously critique our power structures to transform our field into an inclusive and equitable one.

Many marginalized people remain underrepresented in biology (Directorate for Social, Behavioral, and Economic Sciences National Science Foundation 2021). In a society that privileges white people through media, culture, social systems, and institutions, preventing access to marginalized people becomes the norm. While the structure of exclusion and access has changed over time due to the contingency of history, that core baseline of excluding marginalized people remains codified within the culture of science. From Quassi's era to today, marginalized people must pay an immense cultural, community, political, and personal cost to participate in research and have their work acknowledged by the academic community.

Advancements in information technology have already revealed and will continue to allow for the opportunity to acknowledge the legacy of colonialism within the data and open up a broader discussion on the conscious omission of underrepresented voices. Below we discuss how information technology can help to make botany more inclusive, but the field needs to continue to ask the question, as stated by media scholar Wendy Hui Kyong Chun, "... are we updating but remaining the same?" (Chun 2017).

Insights from Specimen Digitization - 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., Page et al. 2015; Drew et al. 2017; Nelson and Ellis 2018; James et al. 2018). Increasing data accessibility holds promise in encouraging people from all backgrounds to explore and create new meaning from these data. Large efforts such as iDigBio (Integrated Digitized Biocollections; www.idigbio.org) and the Global Biodiversity Information Facility (GBIF; www.gbif.org) work to 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 supplemental notes), we found that collector names on specimens only tell part of the story. When we examine the names listed under the collector field, we identify an increase in the number of named contributors over time as well as an increase in ambiguity (**Figure 2**). It appears on the surface that since 1963, more people are receiving credit for making the collections; often students, classes, or people associated with a project, flora, or expedition were lumped into groups, and the individuals are therefore anonymous. Specific student groups have been referred to on herbarium specimens; for example, 'landloopers' refers to students of Valckenier Suringar in the Netherlands (Breteler and 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) utilized these data 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.

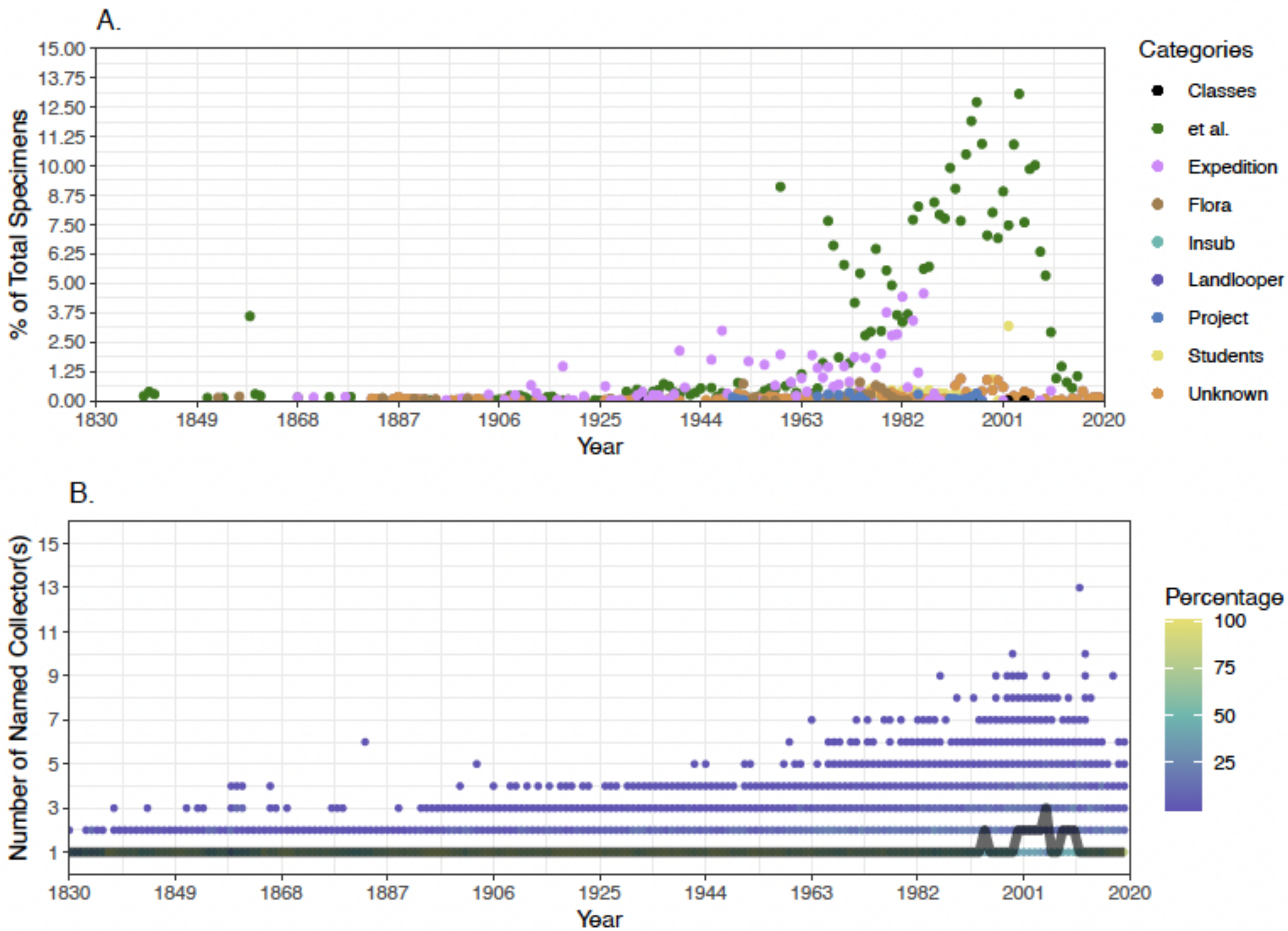

Figure 2. The number of collectors given on each specimen label from 1830 to 2020 for all plant specimens downloaded from iDigBio on June 28th, 2020. (A) Percentage of the total specimens with ambiguous categories (Insub is an abbreviation used to refer to insubordinate). (B) The number of non-ambiguous 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 supplemental note for methods.

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 that users must interact with before accessing the database to search (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.

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 3,000 plants (www.ipni.org/a/23869-1; accessed 11/4/21). While these databases (including 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, Norouzi, and Edmondson 2015; Deng et al. 2017; Vallejos 2021). Efforts to disambiguate authors include assigning unique identifiers such as ORCIDs to researchers (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. Greater care in 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.

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.

Giving a Species a New Name - Based on the International Code of Nomenclature for Algae, Fungi, and Plants (ICN), 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. If two names are given to the same species, and both are considered valid, the accepted or legitimate scientific name then becomes the one that has priority or was published first (principle of priority). The names that are considered valid but not legitimate then become synonyms. Unlike usages of synonyms in other contexts, taxonomic synonyms are not considered correct. Sometimes, however, these names bear a history that can be forgotten when relegated to synonyms. For example, *Cyrtandra frederickii,* mentioned above as an honorific for Dr. Lafayette Frederick, is now considered a synonym to the accepted name, *C. dentata*, in reference to the plant's leaf morphology. Such revisions designate the honorific as incorrect, 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 and Wright 2020; Knapp et al. 2020; Wright and Gillman 2021; Smith and Figueiredo 2022; Thiele et al. 2022). However, these proposals can only be accepted at the International Botanical Congress, a meeting that typically occurs every six years.

Included in these proposals is the suggestion of consciously assigning and reinstating Indigenous names for species, whenever feasible (Gillman and Wright 2020; Knapp et al. 2020; Wright and 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 plant (Gillman and Wright 2020). Providing a path in which Indigenous peoples can submit name changes would likely also have a positive outcome for biodiversity conservation due to the potential for increased engagement by Indigenous peoples (Wilder et al. 2016; Wright and Gillman 2021; Kimbrough 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 and 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.

A New Idea of Ownership - Historically, collections were regarded as the property of one wealthy individual. 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). 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 (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?

The Impacts of Community Science - Perhaps one of the largest efforts to decentralize ownership in botany is the advancement in community science. 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* 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 recent species discovery 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 discovery of *I. viridimontana* was then included as a co-author on the publication describing the species (Uyeda, Stow, and Richart 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).

A Global Movement - Globally, most countries have taken steps to attempt to promote equity in biodiversity research and credit. One such effort, the Nagoya Protocol on access and benefit-sharing (https://www.cbd.int/abs), covers use of genetic resources and traditional knowledge associated with those genetic resources. By ratifying this protocol, participating countries agree to the fair and equitable sharing of benefits arising from the utilization of biological diversity data. The resulting framework helps to prevent exploitation and ensure that Indigenous and local communities receive benefits through a legal framework that respects the value of traditional knowledge associated with future genetic resources. 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 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 more commonly referred to as 'parachute science,' which Marks et al. (2021) argue is rooted in current and historical 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, and access to resources at every level (Marks et al. 2021; McCartney et al. 2022).

Using Technology for Accessibility - Disability represents a form of diversity with accessibility remaining an ongoing issue towards greater inclusivity. The Americans with Disabilities Act (ADA), passed in 1990, followed by 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 US, newly built botanical spaces have increased physical accessibility through building modifications; however, cost continues to be the biggest obstacle to greater inclusion in previously built spaces (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 and Leigh 2018; Brown and Leigh 2020).

Many times, researchers working with plant collections need to perform repetitive motions. Tools such as voice-to-text software or automatic paper cutters could allow access to those with 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 collections doors to disabled scientists. Disabilities can also limit a scientist's access to nature and limit one's ability to participate in fieldwork (Demery and 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 and Vurro 2020).

In the current age of technology, novel and unexpected barriers are forming. It is imperative that we approach the digitization processes with criticality 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.

THE "*RADICLE*" DREAM FOR BOTANY

Botany is facing a tsunami of data, from digitized natural history collections to open-access sequence databases (Nelson and Ellis 2018; Kersey et al. 2020; Cowell et al. 2022). The tension between increasing data, storage, ongoing curation, and the acknowledgment of the historical context reflects the fundamental problems scientists are trying to solve through technology. As ''Big Data'' has become a buzzword in the life sciences, researchers must step back to seriously consider why data are valuable, who determines their usefulness, and what historical meanings contemporary considerations of data might imply. In the wake of the Black Lives Matter movement and calls for decolonization of museums and garden spaces, many institutions have been encouraged or forced by external pressures to begin the process of active inclusion. The process of inclusion not only seeks to expand quality scientific research by broadening perspectives but also to challenge and contextualize the traditional boundaries of science.

A *radical* overhaul of the existing the systems of exclusion that exist today requires mindful and conscious inclusion across gender, race, religion, ability, and sexual orientation as well as recognizing intersectionality. At the same time, we must understand that the ordering of the botanical world was an act of intention, politically and scientifically, and represents an anthropogenic view of nature. This paper has aimed to address the uncomfortable history, or *root*, of botanical research by offering insight into the field's historical past and reflecting on our responsibility in the age of information technology. However, as stated in the introduction, the views expressed here are influenced by the perspectives, personal experiences, and biases of the authors. We hope that this paper will encourage others who possess different positionalities and experiences to collaborate in order to foster an inclusive field of botany.

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AUTHOR CONTRIBUTION

MEM (white/able/straight/cis-female), NC, RSA (Black/dyslexia/queer/non-binary), MLG, KKP (Asian-American/able/queer/non-binary), and TMW 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 the responsibility in the age of technology. KSM, VBS, DES, and PSS provided feedback and edits, added additional plant examples, and historical context where necessary. All authors contributed to the writing and proofing of the final version.

DATA AVAILABILITY STATEMENT

Scripts and data files can be found at https://doi.org/10.5281/zenodo.7595168. Open Education Resource can be found on Qubes - *link will be added after paper acceptance*.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

SUPPORTING INFORMATION

Methods S1. Description of methods used to generate Figure 2.

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The following Supporting Information is available for this article:

Methods S1. Description of methods used to generate Figure 2.

Records where Kingdom = Plantae were downloaded from iDigBio (https://www.idigbio.org/) using the API (https://biodiversity-specimen-data.github.io/specimen-data-use-case/Download_API_example) on June 28th, 2020. We obtained 52,144,789 observations based on our initial search. Records were then filtered to remove observations with missing dates or those that had an event date that was beyond the years 1532 to 2020 (the date of the first established herbarium till the date of our search). All filtering steps were conducted in R v. 4.0 using the functions *data.table* v. 1.14.2 (Dowle and Srinivasan 2021) and *splitstackshape* v. 1.4.8 (Mahto 2019), and multiple packages available in *tidyverse* v. 1.3.1 (Wickham et al. 2019) including *stringr* v. 1.4.0 (Wickham 2019), *ggplot2* v. 3.3.5 (Wickham 2016), *dplyr* v. 1.0.7 (Wickham et al. 2021), and *lubridate* v. 1.8.0 (Grolemund and Wickham 2011). Our final data set contained 1,048,479 records.

We then focused on collector ID (dwc:recordedBy) and attempted to parse collectors' names. Due to inconsistencies, we had to edit each record additionally manually. Once collector names were separated by a semicolon, we were able to investigate how collection credit has changed over the years. We identified 41,996 specimens where collectors were ambiguously designated as belonging to an expedition, flora, or project, all of which are standard practice. Other notable patterns include how those with a lower education rank were credited. We found that 1,466 specimens were collected by groups of students, sometimes grouped by class name or by 'Landloopers'. This practice of grouping individuals, while better than not acknowledging them at all, still prevents credit from being properly assigned. It also still results in a picture where there exist only a few all-knowing experts and prevents the ability to shine a light on all those who participated. Our final figures were plotted with functions available from *ggplot2*, *gridExtra* v. 2.3 (Baptiste and Auguie 2017), and *viridis* v. 0.6.2 (Garnier et al. 2021).

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