

Envisioning a Natural History Collections Action Center

Gil Nelson, Nat Science Collections Alliance, Florida Museum of Natural History, iDigBio
Libby Ellwood, Florida Museum of Natural History, iDigBio
Breda Zimkus, Museum of Comparative Zoology, Harvard University

On behalf of the organizing team:

John Bates, Field Museum of Natural History

Carol Butler, National Museum of Natural History, Smithsonian

Matt Borths, Duke Lemur Center, Duke University

Joe Cook, Museum of Southwestern Biology, University of New Mexico

Jillian Goodwin, Florida Museum of Natural History, iDigBio

David Jennings, Florida Museum of Natural History, iDigBio

Jyotsna Pandey, American Inst of Biological Sciences, Nat Science Collections Alliance

Emily Sessa, New York Botanical Garden

Pam Soltis, Florida Museum of Natural History, iDigBio, UF Biodiversity Institute

Executive Summary

Within the biological collections community there is consensus and growing momentum for the establishment of an Action Center for Biological Collections (i.e., Action Center) to expand the reach and impact of the nation's biodiversity collections and coordinate their initiatives, resources, and data sharing to address the nation's complex and often unpredictable needs and challenges. An Action Center was first suggested in the report of the National Science Foundation (NSF)-funded Biological Collections Network (BCoN, 2019). A similar vision was advanced in 2020 by the National Academies of Science, Engineering, and Medicine (NASEM, 2020). These reports led to codification by the U.S. Congress in the CHIPS and Science Act of 2022, which specifically identified the NSF as the agency to establish a national Action Center for supporting, sustaining, and expanding the scope of biological collections in coordination with other funding agencies.

A series of intensive discussions over several months by approximately 300 biological collections curators, collections managers, museum leaders, research and early career professionals, Artificial Intelligence (AI) experts, and related stakeholders has led to several key conclusions. The recommendations that follow underscore and strengthen the essential role that biological samples and repositories play in medical science, human health, food security, pathogen-borne disease, biosecurity, a strong bioeconomy, mitigating deleterious effects of climate change, and conserving ecological services for human use and subsistence:

- 1. Design and implement a nationwide organizational structure representing the seven geographic areas of the United States (Fig. 2) and including**

stakeholders from local, state, and federal government agencies; business and industry (e.g., agriculture, banking, pharmaceutical, biological and ecological monitoring, medical science, human health, and resource extraction sectors); and the conservation, climate science, and scientific research communities to ensure that collections-based research meets the needs of all stakeholder communities, contributing to national science priorities, strategic economic goals, and defense initiatives.

- 2. Contribute to the bioeconomy by providing customized data services and products in support of conservation-dependent and environmental service industries and related governmental agencies.**
- 3. Drive innovation in national biosecurity initiatives through integrated targeted research in collaboration with the Department of Defense, Department of Energy, Centers for Disease Control and Prevention, U.S. Food and Drug Administration, U.S. Department of Agriculture, and the National Institutes of Health.**
- 4. Establish and monitor short and long-term comprehensive national collecting and sampling plans to achieve unified national goals, including those outlined in 1-3, above, and broad coordination across the collections, research, industrial, medical science and human health communities to ensure strong collaboration and focused direction for addressing grand challenges and NSF's 10 Big Ideas.**
- 5. Establish and coordinate a community-driven national, comprehensive, strategic research framework focused on identifying and filling knowledge gaps and promoting discoveries of national importance.**
- 6. Create, publish, and continuously update an online inventory of existing scientific collections including their locations and holdings to allow researchers, industry leaders, and the general public access to up-to-date scientific collections data and research outcomes.**
- 7. Facilitate biological and biodiversity data aggregation through a nationally designated aggregator, openly available public data portal, and customized, fit-for-use data products designed for industry, biotech companies, medical science, governmental agencies, researchers, and the general public.**
- 8. Promote the development and use of emerging research technologies such as machine learning, artificial intelligence, computed tomography (CT), and others to enhance the bioeconomy, support development of broad-scale data integration and interpretation, and advance nationally designated and coordinated research priorities for the public good.**

9. **Broaden the scope of collections-based research through integration of biological, archeological, anthropological, geological, biomedical, and living collections to enhance research outcomes to broadly benefit society.**
10. **Serve as a knowledge base and clearing house for state, federal, and international permitting, as well as ethical and legal issues.**
11. **Establish protocols, best practices, and recommendations for engaging U.S. Indigenous cultures to ensure the preservation, inclusion, and use of traditional knowledge, while acting within existing CARE guidelines (Collective benefit, Authority to control, Responsibility, and Ethics).**
12. **Develop and oversee strategies for the preservation and digitization of endangered and orphaned collections, many of which were collected through state and federal funding, to protect the public investment against loss of specimens and data critical to U.S. national subsistence and priorities.**
13. **Ensure continuing workforce development and training services that create job placement in evolving technical careers for the existing and emerging labor force, thereby promoting a strong national economy.**
14. **Promote and facilitate collections-based research into the pathology, detection, and mitigation of emerging diseases for the public good in collaboration with relevant stakeholders.**
15. **Maintain engagement, communication, and outreach to all U.S. citizens, keeping them abreast of new discoveries and developments for the public good that have resulted from investments in biological and natural science repositories.**

Establishing an Action Center in Service to National Biological Research and Security

In 2020 an ad hoc committee of the National Academies of Science, Engineering, and Medicine (NASEM) released its report *Biological Collections: Ensuring Critical Research and Education for the 21st Century* (NASEM, 2020). The report advanced several recommendations for sustaining, using, and growing biological collections in the United States. Recommendation 8-1 of the report identifies “*The National Science Foundation, in collaboration with other institutions that provide funding and other types of support for biological collections, [to] help establish a permanent national Action Center for Biological Collections to coordinate action and knowledge, resources, and data sharing among the nation’s biological collections as they strive to meet the complex and often unpredictable needs of science and society. Such an action center should include a physical space and cyberinfrastructure to develop and*

implement collaborative strategic efforts and further build and nurture communities of practice for research, education, workforce training, evaluation, and business model development, among other community-wide needs.”

The NASEM report was preceded in 2019 by the report of the Biological Collections Network (BCoN), *Extending U.S. Biodiversity Collections to Promote Research and Education* (BCoN, 2019), an NSF-funded Research Coordination Network awarded to the American Institute of Biological Sciences (AIBS) (Lendemer, et al., 2020), which proposed the establishment of an integrated Extended Specimen Network (ESN) and suggested that sustaining the ESN will require "a central organizing unit funded over a much longer time horizon than currently supported by any existing grant program. Building upon the national digitization hub (iDigBio) established in the Advancing Digitization of Biodiversity Collections (ADBC) program, a securely funded coordinating center would maintain the data network and partner with collections institutions and professional societies. Such a collaboration would support the stakeholder community in sharing techniques, resources, and strategies for outreach while demonstrating the value of collections. We suggest that the creation of a distributed platform as ubiquitous and indispensable as the NCBI-managed GenBank database, with similar open-ended funding, is required for the ESN to reach its full potential (BCoN, 2019)". NASEM's Action Center and BCoN's Central Organizing Unit express a clear community preference for an entity that can provide ongoing services which individual collections are challenged to provide for themselves.



Fig 1. NEON sites and museum collections dispersed broadly throughout the U.S., providing access to a breadth of complementary data and resources.

In the summer of 2022, the U.S. Congress authorized and codified NASEM's Action Center recommendation as part of the CHIPS and Science Act of 2022. Following passage of the CHIPS Act, in an effort to launch a broadly inclusive visioning process among the collections community, the authors established an organizing team to pursue a series of webinars, workshops, focus groups, conference symposia, and related activities. The aim of these activities was to discuss the potential structure, products, and services an Action Center or organizing unit could pursue to support, sustain, expand, and

augment natural science collections by harnessing the momentum of several previous large-scale U.S. initiatives relating to the preservation and expanded research use of biological collections. These initiatives include the creation of the National Museum of

Natural History Smithsonian (NMNH), which opened in 1910 and is arguably the largest natural history museum in the world with approximately 150 million specimens; the National Ecological Observatory Network (NEON), funded in 2011 by the National Science Foundation (NSF), National Science Board, and Congress with biological specimens and samples deposited at Arizona State University; and Integrated Digitized Biocollections (iDigBio), launched by NSF in 2011 through the Florida Museum of Natural History and now serving about 140 million digitized specimen records and 53 million associated media records from ~1,000 biodiversity collections. We envision an action center of sufficient scale, scope, and longevity to integrate and thereby expand the quantity and quality of data and research outcomes and to provide scientific research coordination, integration, and impact across the vast landscape of federal and non-federal public collections and data resources.

The initial webinar series

(https://www.idigbio.org/wiki/index.php/Envisioning_a_Biological_Collections_Action_Center) was offered in March 2023 and included authors of the NASEM report and representatives from the Interagency Working Group on Scientific Collections (IWGSC), AIBS, and BCoN. The three-part webinar series was designed to act as a primer for three subsequent workshops (https://www.idigbio.org/wiki/index.php/Envisioning_a_Biological_Collections_Action_Center) held at the New York Botanical Garden, the Field Museum of Natural History, and the Natural History Museum of Los Angeles County.

By design, participants in these activities included a broad spectrum of professionals from biodiversity collections, natural science museums, and academic institutions, as well as researchers and collections-related beneficiaries, to address how an Action Center might engage critical stakeholders and collaborators to benefit the larger society. Curators, collections managers, and institutional administrators ensured on-the-ground perspectives. Biodiversity scientists focused on collections-based research to address grand-challenge questions in medicine and human health, pandemic mitigation, expanding and sustaining the bioeconomy, and ensuring biosecurity in support of the broader goals of national security. Biodiversity informaticians, computer and data scientists, and software developers stressed the importance of expanding, linking, and integrating biodiversity data into ever-growing databases, knowledge graphs, data lakes, and information networks for increased efficiency and faster access to relevant research data from disparate sources and domains. The varied perspectives of participants collectively emphasized the critical need of collections, and an organized collections community, for contributing to research, education, and to addressing societal challenges (Nanglu et al. 2023).

Summary of Outcomes and Recommendations (Potential Features of an Action Center)

Organizational structure. To ensure the involvement of the entire collections community and its numerous stakeholders and beneficiaries, the Action Center will be organized following a hub and spoke model with a central administrative hub (location to

be determined) with offices distributed in seven geographic regions across the US (Fig. 2). This is similar to NSF's successful organization of its Advancing the Digitization of Biodiversity Collections (ADBC) program and the National Ecological Observatory Network (NEON). These models have been widely discussed within the workshops. In general, the community expressed a desire for an organization with accountable leadership that operates with internal and external input with the following potential features:

- An executive committee and director with fiduciary responsibilities that include high-level decision making and strategic planning,
- A national advisory board with rotating leadership and membership from institutions and critical stakeholders throughout the U.S.,
- Regional advisory boards of regional stakeholders, and
- Reliance on external evaluators and auditors.

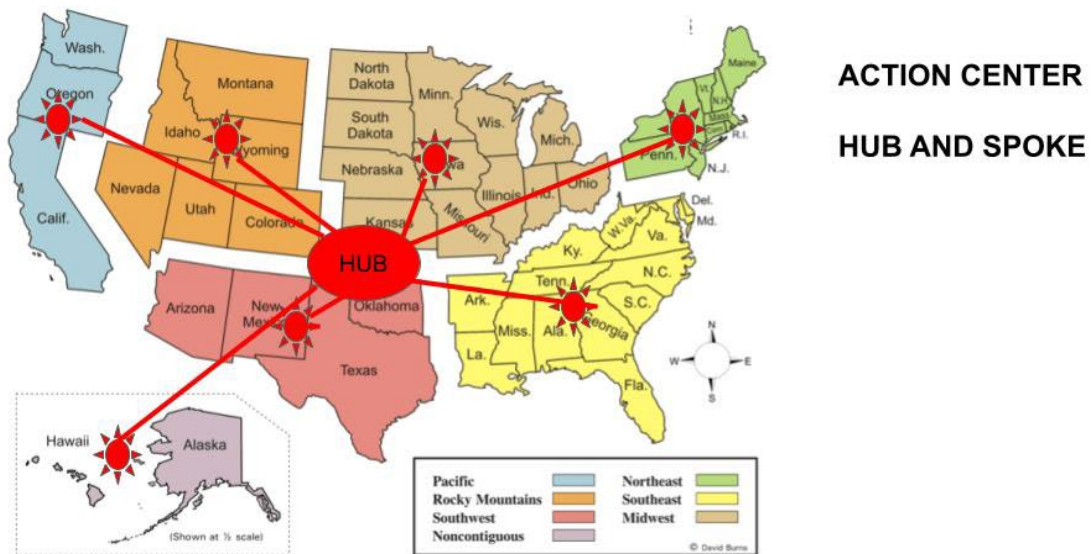


Fig 2. Hub and spoke model of Action Center organization.

Strengthening the Bioeconomy. Bioeconomy has been defined as economic activity driven by research and innovation in the life science and biotechnology sectors that is enabled by technological advances in engineering, computing, and information sciences. An Action Center will leverage our understanding of the natural world to support novel applications of bio-based products that are sustainable and have a smaller impact on the environment than their conventional counterparts. The impacts of these products extend to and benefit numerous sectors of the economy while also providing an income stream for the researchers and institutions providing the biological components. See Executive Order: “*Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe and Secure American Bioeconomy*” for additional

information.

Enhancing Biosecurity. Biosecurity prevents the introduction of pathogens and reduces their spread, playing an important role in optimizing the health of humans, animals, plants, and the environment as part of the One Health approach. Given that the majority of emerging infectious diseases are zoonotic in origin, the Action Center will ensure that biodiversity collections are effectively leveraged to help understand the emergence and reemergence of pathogens with specimens serving as drivers of innovation and vouchers for biosecurity analysis.

Creating a Comprehensive National Plan to Guide Sampling and Research.

Biological, archeological, anthropological, ethnographic, and geological collections are hundreds of years old and make significant contributions to the knowledge within the earth, medical, biological, agricultural, paleontological, and biodiversity sciences. More importantly, new discoveries continue in all of these fields, leading to development and use of new technologies through bioinspired design, more efficient and effective research methods and protocols, and expanded understanding of diseases and their treatments. The Action Center will create and oversee a comprehensive national specimen collecting and environmental sampling plan aimed at solving society's grand challenge questions (e.g., coordinated biosolutions and predictive modeling to address the challenges of climate change and enhancing resiliency through mitigation of pandemics and emerging infectious diseases, harnessing collections data to 'future-proof' global networks of food, water, and other life-sustaining natural resources, promoting the continuation of collecting throughout time, identifying global, regional, and taxonomic gaps in specimen collecting, increasing the rate of discovery through new technologies, and providing U.S. leadership for a Global Access and Benefits Sharing Network).

Providing an Inventory of Biodiversity Collections. Collaborating with other national and international initiatives (e.g. iDigBio, NMNH, GBIF, Index Herbariorum, TDWG (Biodiversity Information Standards)) the Action Center will curate and host an online inventory of biologically related repositories.

Broadening the Scope. While the collections professionals represented in these workshops, webinars, and discussion activities firmly support the establishment of an Action Center to strengthen and sustain biological research collections and their sponsoring institutions, they also recognize that many U.S. natural science and natural history museums include archeological, anthropological, geological, biomedical, and living (e.g., zoos, botanic gardens, microbial repositories) collections. These allied collections underscore, augment, and contribute to biological and biodiversity research in numerous ways that expand our understanding of biodiversity's place in the sustainability of human life. Incorporating these collections under the purview of an Action Center and the strategic collecting and research frameworks it develops will further promote important cross-disciplinary research and data integration in ways that enhance holistic discovery and application.

Permanence and Sustainability. The NASEM report called for the proposed Action Center to be made permanent, meaning that it would be positioned to provide leadership for integrated, collaborative, and coordinated high-value research well into the future. This feature of the recommendation was not carried over into the legislative authorization, which suggests that this decision be left to the NSF or another federal agency. While a permanent center is strongly preferred by collections community representatives, it is necessary that the center last sufficiently long to launch and support a variety of upcoming initiatives, many of which are addressed herein.

Ensuring Broad-scale Data Integration through Establishment and Coordination of a Digital Extended Specimen Network. The BCoN report heavily stressed the establishment of an Extended Specimen Network to provide automated tools and strategies for connecting, linking, and integrating specimen data with sources of ecological, environmental, systematic, genomic, archeological, geological, ethnographic, and other types of biodiversity and earth science data to augment and broaden what is known about the Tree of Life. Since the BCoN report was released, several publications (Lendemer, et al, 2020; Hardisty, Ellwood, Nelson, et al. 2021; Islam et al. 2023) and numerous conference papers and symposia have been published or presented, leading to broad interest in the Digital Extended Specimen Network concept and its design and implementation. The Action Center will:

- Play a critical, coordinating role in building out this integrated network to more effectively track the sources of global disease,
- Create and oversee the permanent, AI-ready cyberinfrastructure required to link the vast types of data, people, institutions, knowledge, and research that enable novel applications and discoveries,
- Create and build the infrastructure necessary to store the expanded quantity of data needed to address societal demands.

Linking and integrating existing and newly collected sampling data will facilitate a clear and comprehensive story of life on earth including the interconnectedness of organisms and ecological services in ways that strengthen the bioeconomy, bolster biosecurity, and promote human health and prosperity (Interagency Working Group on Data for the Bioeconomy, 2023).

Creating a Unified, Large-scale, Targeted Sampling Framework. For much of its 300–400-year history, biological and natural science expeditions to collect specimens were focused on the goals of a single collector pursuing individual research or discovery, and targets were often related to specific geographic regions, taxonomic entities, or researcher-defined questions. The Action Center’s National Collecting Plan will establish and coordinate a community-driven national, comprehensive, coordinated, strategic, scheduled sampling and research framework focused on filling currently recognized knowledge gaps, addressing timely societal issues, and promoting discoveries from groups of scientists pursuing unified research.

Providing a Knowledge Base, Clearing House, and Best Practices for State, Federal, and International Permitting. The Action Center will serve as the U.S. collection community’s clearing house and information center for national and

international permitting as well as the leading resource for state, federal, and country-specific collecting policy. It will provide advice, support, and counsel for ethical and legal issues, a Ready Response Team for time-sensitive issues, and expertise that interprets information for researchers. The knowledge base and clearing house will also serve in the development of ethical and legal best practices.

Engaging Indigenous Cultures. The Action Center will establish a collaborative advisory committee consisting of representatives of Native American tribes and communities, those working with these entities, and collections professionals and biodiversity informaticians, to collaborate on issues specific to Native American communities and Indigenous data. The committee will be grounded in consultation between Indigenous and collections communities to facilitate development of respectful, well-considered, and sustainable collecting and data management practices that follow CARE data principles and emphasize stewardship versus ownership of collections from recognized and unrecognized tribal lands.

Preserving and Digitizing Orphaned Collections and Other Endangered Specimens. Smaller collections stored in resource-challenged institutions are in particular danger of becoming orphaned and potentially lost to science. Traditionally, such collections have been transferred and incorporated into larger, better-funded institutions, especially institutions with similar collection and research scopes, and with the resources to recognize the value and contribution of the often-unique specimens these smaller collections hold. This expands the resource of the receiving collections and preserves specimens in danger of being lost. The National Science Foundation has assisted in funding some of these transfers through special projects but no comprehensive method or organization currently exists to identify, inventory, and facilitate orphan collections transfer and preservations. The Action Center will provide this service.

Provisioning Workforce Development and Training Services. Through its continued funding of Integrated Digitized Biocollections (iDigBio) and a variety of collections-based and workforce development networks, NSF has successfully promoted a massive capacity-building program to grow and ensure a digitization and data mobilization effort serving more than 25,000 collections professionals from more than 1,000 of the approximately 1,600 biodiversity and natural science collections across the U.S. This training has resulted in the development and growth of iDigBio's U.S. biodiversity data portal referenced above. The Action Center will enhance and sustain these successes and provide leadership for:

- Recruiting and training the biodiversity informaticians, data scientists, and computer engineers needed to develop and manage large-scale data integration across all domains of the life and environmental sciences,
- Providing advanced in-service training for the current workforce, and
- Broadening participation in the collections-related professions.

Engaging and Communicating with the Public. Effective communication of noteworthy discoveries to non-scientists, the wider public, and local, state, and federal

government partners is a well-known gap in all but the larger and better-funded collections-holding institutions. Although several important articles extolling the research and societal value of collections have been published in the popular press (Soltis, et al., 2020; Zimmer 2023), too few articles authored by well-informed science writers skilled in interpreting research findings through publicly accessible prose appear in broadly distributed general interest newspaper, magazine, and broadcast media. The Action Center will include a subunit of skilled science communicators and journalists and will develop a network of media and governmental access points dedicated to keeping the public and its governmental representatives apprised of sampling and collections-based outcomes that impact the human condition.

Promoting the Development and Use of Emerging Research Technologies (Machine Learning, Artificial Intelligence, Computed Tomography (CT), and Others). Biological research, like other facets of today's society, is increasingly turning to emerging technologies to improve efficiency and efficacy of the work we do. Data digitization and mobilization benefit greatly from machine learning and artificial intelligence as computing technology is leveraged for tasks like optical character recognition, morphological and phenological studies, species identification, etc. These technologies are also used for more complex research applications in systematics, evolution, and image analysis for conservation. Institutional support for this work is growing, as evidenced by a recently created Curator of Artificial Intelligence position at the University of Florida, departmental commitments to technology-aided research such as in the Data Science Lab at the Smithsonian, and a seemingly endless list of university classes on the topic. However, given the substantial technological and human resources necessary to work in this area, not all institutions are readily able to contribute to the field. An Action Center will enable and support collaborations between biological researchers and computer scientists, along with the digital data necessary for the work.

Supporting conservation-dependent industries. Conservation-dependent industries compose a large and expanding group of stakeholders benefiting from biodiversity collections. This includes conservation biologists as well as adjacent fields. Agriculture, agribusiness, and aquaculture-- which rely on pollinators or other biological associates -- face challenges due to a growing human population and climate change and would benefit from an understanding of wild relatives (Mabry et al. 2021). The environmental service industry relies on environmental and specimen data for tracking and assessing landscape suitability for development, conservation easements, and preservation. Forestry depends on strategic management for trees as well as the biota that forests support, thereby helping curb catastrophic loss of biodiversity. Ecotourism brings in billions of dollars to the U.S. economy and is entirely sustained by healthy, biodiverse ecosystems. An Action Center will support efforts that bring entities representing these industries into collaboration with collections and other biodiversity data resources to provide the information necessary for effective decision-making.

References

- BCoN. 2019. *Extending U.S. Biodiversity Collections to Promote Research and Education*. American Institute of Biological Sciences, Washington DC.
https://bcon.aibs.org/wp-content/uploads/2019/04/BCoN_March2019_FINAL.pdf
- CHIPS and Science Act. 2022. <https://www.congress.gov/bill/117th-congress/house-bill/4346>
- GBIF. 2023. Scoping study explores a global nature-related public data facility.
<https://www.gbif.org/news/5YXFGAx3syqlZ2ljoJDikb/scoping-study-explores-a-global-nature-related-public-data-facility>.
- Hardisty AR, Elizabeth R Ellwood, Gil Nelson, Breda Zimkus, Jutta Buschbom, Wouter Addink, Richard K Rabeler, John Bates, Andrew Bentley, José A B Fortes, et al. 2022. Digital Extended Specimens: Enabling an Extensible Network of Biodiversity Data Records as Integrated Digital Objects on the Internet *BioScience*, 72:10.
<https://doi.org/10.1093/biosci/biac060>
- Interagency Working Group on Data for the Bioeconomy. 2023. Vision, Needs, and Proposed Actions for Data for the Bioeconomy Initiative. National Science and Technology Council. <https://www.whitehouse.gov/wp-content/uploads/2023/12/FINAL-Data-for-the-Bioeconomy-Initiative-Report.pdf>
- Islam, S., Beach, J., Ellwood, E.R., Fortes, J., Lannom, L., Nelson, G. and Plale, B., 2023. Assessing the FAIR Digital Object Framework for Global Biodiversity Research. *Research Ideas and Outcomes*, 9, p.e108808.
- Lendemmer, J., Barbara Thiers, Anna K Monfils, Jennifer Zaspel, Elizabeth R Ellwood, Andrew Bentley, Katherine LeVan, John Bates, David Jennings, Dori Contreras, et al., 2020. The Extended Specimen Network: A Strategy to Enhance US Biodiversity Collections, Promote Research and Education. *BioScience*, 70:1, Oxford University Press. <https://doi.org/10.1093/biosci/biz140>
- Mabry, M.E., Turner-Hissong, S.D., Gallagher, E.Y., McAlvay, A.C., An, H., Edger, P.P., Moore, J.D., Pink, D.A., Teakle, G.R., Stevens, C.J. and Barker, G., 2021. The evolutionary history of wild, domesticated, and feral *Brassica oleracea* (Brassicaceae). *Molecular Biology and Evolution*, 38(10), pp.4419-4434.
- Nanglu, K., de Carle, D., Cullen, T. M., Anderson, E. B., Arif, S., Castañeda, R. A., Chang, L. M., Iwama, R. E., Fellin, E., Manglicmot, R. C., Massey, M. D., & Astudillo-Clavijo, V. (2023). The nature of science: The fundamental role of natural history in ecology, evolution, conservation, and education. *Ecology and Evolution*, 13, e10621.
<https://doi.org/10.1002/ece3.10621>
- NASEM. 2020. *Biological Collections: Ensuring Critical Research and Education for the 21st Century*. National Academies of Science, Engineering, and Medicine.

<https://nap.nationalacademies.org/catalog/25592/biological-collections-ensuring-critical-research-and-education-for-the-21st>

Soltis P, Cook J., Yanagihara R. 2020. Museums Preserve Clues That Can Help Scientists Predict and Analyze Future Pandemics. *Nature World News*, <https://www.natureworldnews.com/articles/43979/20200625/museums-preserve-predict-analyze-future-pandemics.htm>

Zimmer, C. 2023. Science Museums Take Stock of 1.1 Billion Objects From Around the World. *New York Times*, March 23, 2023. <https://www.nytimes.com/2023/03/23/science/science-museums-online-collections.html>

Workshop Attendees

Attendee	Affiliation	Workshop Attended
Alyson Elizabeth Wilkins	Natural History Museum of Utah	Field
Charles George Willis	University of Minnesota	Field
Christopher Meyer	Smithsonian National Museum of Natural History	Field
David Ronald Nobles	University of Texas	Field
Dawn R. Roberts	Chicago Academy of Sciences / Peggy Notebaert Nature Mu:	Field
Diane DiEuliis	National Defense University	Field
Dori L. Contreras	Perot Museum of Nature and Science	Field
Edward Erik Gilbert	Arizona State University, Symbiota Support Hub, iDigBio	Field
Emily Marie Braker	University of Colorado, Boulder	Field
Frances Ann Hitchcock	National Park Service	Field
Gregory Jon Watkins-Colwell	Yale Peabody Museum	Field
James H Beach	Specify, University of Kansas	Field
Janeen M Jones	Field Museum	Field
Jorrit Hoite Poelen	Cheadle Center for Biodiversity and Ecological Restoration	Field
Katherine Webbink	Field Museum	Field
Kelly Anne Speer	University of Michigan	Field
Lisa Christine Niziolek	Field Museum	Field
Matthew von Konrat	Field Museum	Field
Michael Stilson Webster	Cornell University	Field
Paul Stephen Mayer	Field Museum	Field
Petra Sierwald	Field Museum	Field
Prosanta Chakrabarty	Louisiana State University	Field
Randy Singer	University of Michigan	Field
Robert Curtis Jadin	University of Wisconsin Stephens Point, Museum of Natural H	Field
Ruediger Bieler	Field Museum	Field
Sharon Grant	Field Museum	Field
Aisling Farrell	Natural History Museum of Los Angeles County	NHMLA
Allison Shultz	Natural History Museum of Los Angeles County	NHMLA
Amy Gusick	Natural History Museum of Los Angeles County	NHMLA
Andres Lopez	University of Alaska Museum	NHMLA
Arthur Porto	Florida Museum of Natural History	NHMLA
Ashley Dineen	UC Berkeley	NHMLA
Austin Hendy	Natural History Museum of Los Angeles County	NHMLA
Az Klymiuk	University of Manitoba	NHMLA
Catherine Michele Early	Science Museum of Minnesota	NHMLA
Chandra Earl	Bishop Museum	NHMLA
Christina Noel Piotrowski	California Academy of Sciences	NHMLA
Cody Welford Thompson	University of Michigan	NHMLA
Conrad Lamoraal Schoch	National Institutes of Health	NHMLA
Dean Pentcheff	Natural History Museum of Los Angeles County	NHMLA
Gary Joseph Motz	Yale Peabody Museum of Natural History	NHMLA
Holly Little	Smithsonian National Museum of Natural History	NHMLA
Jacqueline Emily Chapman	Smithsonian Libraries	NHMLA
Jann Vendetti	Natural History Museum of Los Angeles County	NHMLA
Jennifer M. Zaspel	Milwaukee Public Museum	NHMLA
Joseph Thomas Miller	GBIF	NHMLA

Workshop Attendees

Julia Allen	Virginia Tech	NHMLA
Juliet Hook	Natural History Museum of Los Angeles County	NHMLA
Katelin Pearson	Arizona State University, Symbiota Support Hub, iDigBio	NHMLA
Katharina Dittmar	National Science Foundation	NHMLA
Katja Seltmann	UC Santa Barbara	NHMLA
Kayce Bell	Natural History Museum of Los Angeles County	NHMLA
Kristen Lenay Lewers	UC Boulder	NHMLA
Larry M. Page	Florida Museum of Natural History	NHMLA
Lindsay Jane Walker	Arizona State University, Symbiota Support Hub, iDigBio	NHMLA
Lisa Diane White	UC Berkeley	NHMLA
Luis M. Chiappe	Natural History Museum of Los Angeles County	NHMLA
Maribeth Latvis	University of Arkansas	NHMLA
Maureen Walsh	Natural History Museum of Los Angeles County	NHMLA
Melissa Tulig	Bishop Museum	NHMLA
Patricia Holroyd Vychodil	UC Berkeley	NHMLA
Paula Mabee	NEON	NHMLA
Peter Timothy Oboyski	UC Berkeley	NHMLA
Rebecca Nicole Johnson	Smithsonian National Museum of Natural History	NHMLA
Regina Wetzer	Natural History Museum of Los Angeles County	NHMLA
Scott Edwards	Harvard University	NHMLA
Todd Clardy	Natural History Museum of Los Angeles County	NHMLA
Trina Roberts	Natural History Museum of Los Angeles County	NHMLA
Vijay Barve	Natural History Museum of Los Angeles County	NHMLA
Warren Martin Cardinal-McTeague	University of British Columbia	NHMLA
Young Ha Suh	Natural History Museum of Los Angeles County	NHMLA
Austin Mast	Florida State University, Robert K. Godfrey Herbarium, iDigBi	NYBG
Barbara Thiers	BCon, New York Botanical Garden	NYBG
Bill Moser	Smithsonian National Museum of Natural History	NYBG
Christine Johnson	American Museum of Natural History	NYBG
Hilary Swain	Archbold Biological Station	NYBG
Jose Fortes	University of Florida, College of Electrical and Computer Eng	NYBG, NHMLA
Kelcie Brown	New York Botanical Garden	NYBG
Kevin Hackett	United States Department of Agriculture	NYBG
Kimberly Watson	New York Botanical Garden	NYBG
Larry Gall	Yale Peabody Museum of Natural History	NYBG
Leanna McMillin	New York Botanical Garden	NYBG
Matthew Pace	New York Botanical Garden	NYBG
Nelson Rios	Yale Peabody Museum of Natural History	NYBG
Nicole Tarnowsky	New York Botanical Garden	NYBG
Patrick Sweeney	Yale Peabody Museum of Natural History	NYBG
Roland Roberts	National Science Foundation	NYBG
Scott Miller	Smithsonian National Museum of Natural History	NYBG
Shirley Pomponi	Harbor Branch Oceanographic Institute, Florida Atlantic Unive	NYBG
Steve Ellis	National Science Foundation	NYBG
Talia Karim	UC Boulder	NYBG
Andrew Charles Bentley	University of Kansas	NYBG, Field
Carol Roetzel Butler	Smithsonian National Museum of Natural History	NYBG, Field

Workshop Attendees

John Bates	Field Museum	NYBG, Field
Jyotsna Lavanya Pandey	American Institute of Biological Science, Natural Science Coll	NYBG, Field
Breda Marie Zimkus	BCoN, MCZ, Harvard University	NYBG, Field, NHMLA
David Jennings	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Douglas Stephen Jones	Florida Museum of Natural History	NYBG, Field, NHMLA
Gil Nelson	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Jesse Grosso	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Jillian Varkas Goodwin	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Lauren Cohen	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Libby Ellwood	University of Florida, Florida Museum, iDigBio	NYBG, Field, NHMLA
Matthew Robert Borths	Duke Lemur Center	NYBG, Field, NHMLA
Emily Butler Sessa	New York Botanical Garden	NYBG, NHMLA
Jennifer Megann Yost	Cal Poly, Symbiota Support Hub, iDigBio	NYBG, NHMLA
Joseph Cook	University of New Mexico	NYBG, NHMLA
Pamela Sue Soltis	University of Florida, Florida Museum, iDigBio	NYBG, NHMLA