

Biological Collections: Ensuring Critical Research and Education for the 21st Century

Report Highlights
October 1, 2020

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Motivation for the Study

- Biological collections are an invaluable, and often irreplaceable, component of the nation's scientific enterprise.
- Their health depends on the underlying infrastructure that assembles, maintains, and provides access to the collections.
- Sustainability of the nation's biological collections is under threat:
 - Lack of understanding of their value and contributions to research and education
 - Lack of appreciation for what is required to maintain them effectively
 - Inadequate coordination and interconnection among and between collections
- Without changes in support and organization, prior and current investments for building the nation's biological collections will be diminished, and their immense potential will be severely limited.



Statement of Task (abbreviated)

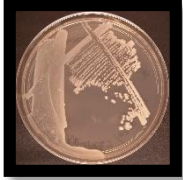
NSF recognizes the breadth of needs for maintaining biological collections exceeds the capabilities of any one federal agency.

NSF asked NASEM for guidance on questions regarding long-term sustainability, including operational structures, policies, and social cultures that could provide momentum to maintain and grow biological collections.

- Explore the contributions of biological collections of all sizes and institutional types to research and education.
- Envision future innovative ways in which biological collections can be used to advance science.
- Outline the critical challenges to and needs for use and maintenance of biological collections.
- Suggest a range of long-term strategies that could be used for their sustained support.



What are biological collections?



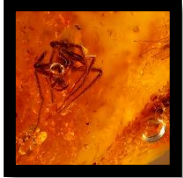
Biological collections typically consist of organisms (specimens) and their associated biological material, such as preserved tissue and DNA, along with data—digital and analog—that are linked to each specimen.



Non-living specimens include organisms preserved by scientists and naturally preserved remains, such as fossils, commonly referred to as natural history collections, some 800 to a billion specimens in 1,800 collections.



Living specimens include research and model organisms that are grown and maintained in genetic stock centers, germplasm repositories, or living biodiversity collections. There are at least 2,855 living stock collections in the U.S.



Focused on collections that receive, or are eligible to receive, support for infrastructure or digitization from NSF, excluding zoos, aquaria, or botanical gardens; biobanks or repositories of human tissues.



The Committee's Approach

- Committee's expertise, peer-reviewed literature, and information-gathering events.
- Identified areas of tension that stem from the scope of the study and that are inherent within the biological collections community:
 - Collections are diverse—taxonomically, organizationally, and in their missions and needs.
 - The communities surrounding collections operate largely independently of one another.
 - There are inherent differences between living stock collections and natural history collections.
- The report is intended to launch a national conversation about the future of biological collections.



The Committee's Vision

For biological collections to survive and thrive...

Provide long-term support for collections-based scientific research, *instill* a culture of stewardship for and access to biological specimens, *build and grow* biological collections to better represent global biodiversity in space and time, *promote* access to biological collections as important educational resources for the general public, and *encourage* the exchange of biological resources and knowledge.



Report Roadmap

- In chapters 2 and 3, the committee highlights ways in which biological collections contribute to science, education, and society.
- The committee recognizes that future success of biological collections depends on addressing four interrelated issues:
 - 1) Upgrade and maintain physical infrastructure and growth of collections (Chapter 4);
 - 2) Develop and maintain tools and processes needed to transform digital data to an easily accessible and integrated cyberinfrastructure (Chapter 5);
 - 3) Recruit, train, and support the workforce of the future (Chapter 6); and
 - 4) Ensure long-term financial sustainability (Chapter 7).
- Realizing the committee's vision will require enhanced communication and collaboration within the biological collections community and beyond (Chapter 8).



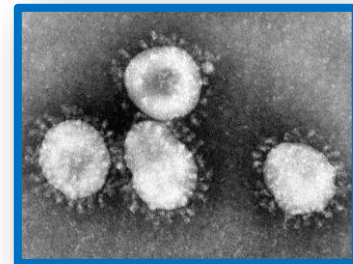
Biological collections advance discovery, inspire innovation, advance education, and inform societal challenges.

- A vast, data-rich repository
- Fundamental support for scientific research and education
 - Preserve and expand knowledge
 - Enable biological discoveries
 - Drive innovation
 - Widen understanding of complex societal issues
 - Unanticipated uses
 - Prepare the next generation of scientists
- Evaluate impacts using metrics for research and education



Examples of Contributions of Biological Collections

- **Monitoring Changes in Environmental Quality**
 - Birds of prey - Assessing environmental quality based on presence of contaminants
- **Understanding and Forecasting Effects of Climate Change**
 - Vertebrates in Yosemite - Document changes in elevation, abundance, and body size of species
- **Ensuring Food Security and Crop Management**
 - Herbarium records - Sighting of wild relatives to collect new germplasm
- **Improving National Safety and Public Health**
 - All biological collections - Identify distribution, reservoirs, vectors, and surveillance over time of pathogens



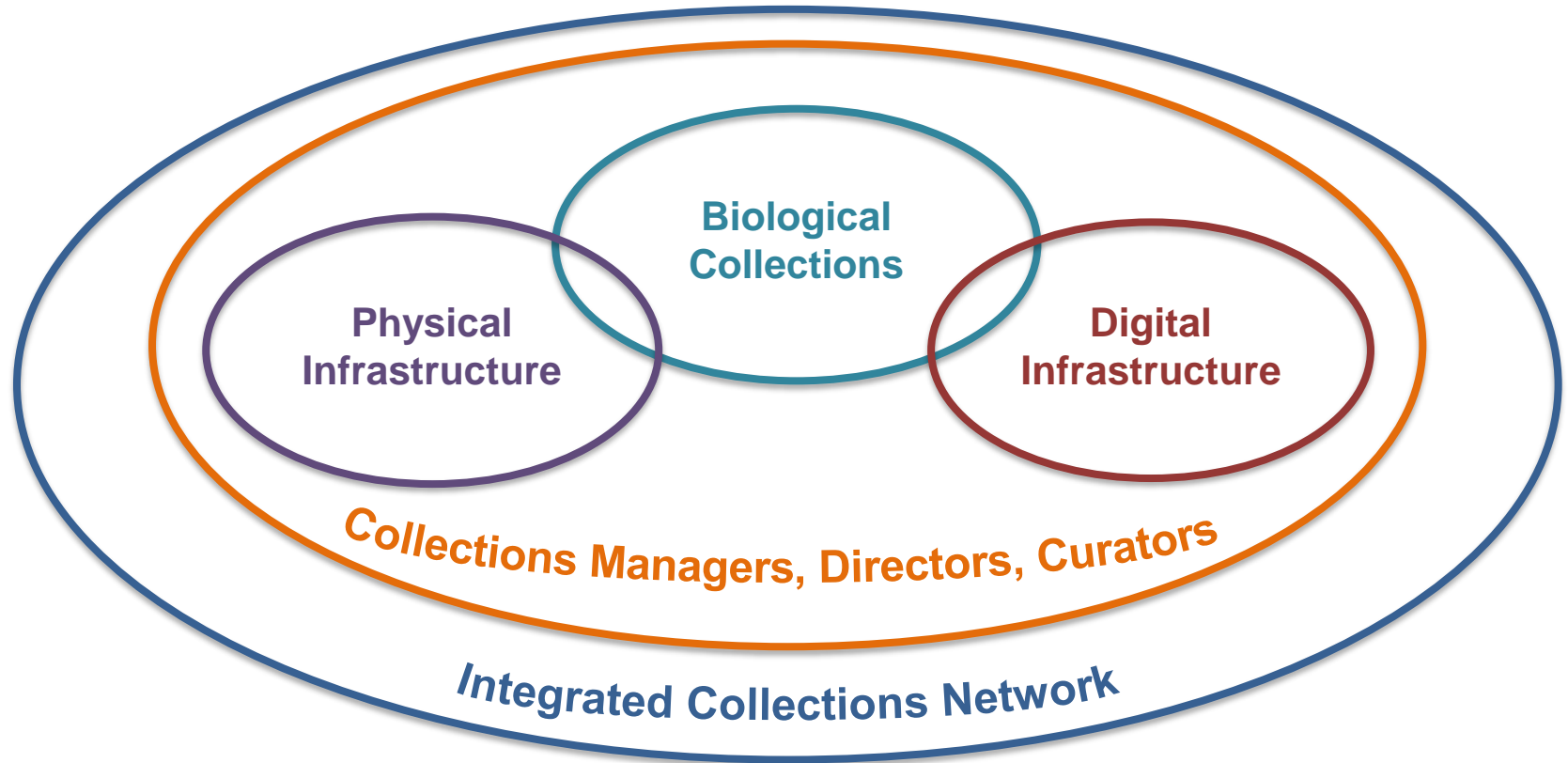
Biological collections contribute to NSF's Big Ideas.

- **Growing Convergence Research:** Chapter 2 of this report presents a range of opportunities that garner the power of convergence through transdisciplinary research using specimens and their extended data.
- **Understanding the Rules of Life - Predicting Phenotypes:** Chapter 2 of this report provides the past, present, and future contributions of living and non-living collections to fulfill this goal.
- **Harnessing the Data Revolution:** Chapter 5 of this report describes the important ways digital data are used to benefit research in yet unimaginable ways.
- **Navigating the New Arctic:** Chapters 2 and 8 lay the foundation for understanding the critical role that collections play in understanding and documenting changing conditions in the Arctic.
- **NSF Includes:** Chapter 6 of this report focuses on workforce and includes diversity and inclusion.
- **Mid-Scale Research Infrastructure:** This report as a whole describes how biological collections are an essential element of the life science research infrastructure (see Chapter 4).

Recommendations for Collaborative Action

- NSF should 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.
- NSF should [lead efforts to develop a vision and strategy, such as a decadal survey](#), for targeted growth of the nation's biological collections, their infrastructure, and their ability to serve a broader range of users and scientific and educational needs.
- NSF should [expand partnership capabilities more broadly across NSF, other federal agencies, international programs, and other sectors to maximize investments](#).

Infrastructure has many intersecting components.



Report Structure

- Each Chapter lays out main challenges for all collections and path forward for the biological collections community.
- Recommendations are offered to:
 - The leadership (directors, managers and curators) of biological collections
 - The biological collection community (professional societies, associations, coordination network etc..)
 - The NSF Directorate for Biological Sciences



Selected Recommendations for the Leadership of Biological Collections (directors, managers and curators)

- **Assess and define the infrastructure needs** of their individual facilities and **develop comprehensive strategic plans** in accordance with those needs and their strategic missions (4.1).
- **Work with business strategists and communication experts to develop business models** for financial sustainability and infrastructure of biological collections (7.1).
- **Collaborate to develop and strengthen the workforce pipeline through community-level action** on issues such as critical skills, workforce analysis, diversity, equity, and inclusion, education and training coherence and alternative staffing models (6.1).

Selected Recommendations for the Biological Collections Community (professional societies, associations, and coordination networks)

- Collaborate and combine efforts aimed at addressing community-level infrastructure needs of the nation's biological collections (4.3).
- Initiate and cultivate opportunities for research collaborations within the biological collections community, including computer and data sciences communities (5.2).
- Develop extensive networked training and platforms for sharing best practices for financial management, and planning and business models for collections of all sizes and types (7.2).

Selected Recommendations for the NSF Directorate for Biological Sciences

- Continue to provide [stable, long-term funding to support investigators who rely on biological collections for research and education](#) (7.3).
- Continue to provide funding support for:
 - [biological collections infrastructure](#) and expand endeavors to coordinate support [within and beyond the Directorate](#) (4.4).
 - [digitization of biological collections and cyberinfrastructure](#) to support [both](#) living and natural history collections (5.3).
- Support initiatives that focus explicitly on systemic, systematic, and [thoughtful development of the biological collections workforce pipeline](#) (6.2).

Taking Collaborative Action: Time to Act Is Now

- Biological collections provide the temporal, spatial, and taxonomic samples needed to **document effects of changes in the biodiversity of natural and managed ecosystems**.
- More than ever, biological collections have an **energized community ready to step up** to meet basic biological and societal challenges.
- Many of the recommendations are **beyond the capability of individual collections to implement**.
- **Several research communities have established central hubs, multi-tiered networks, associations, or synthesis centers**, funded through NSF grants or other federal and state support.
- The biological collection community could **leverage the organizational structure of centers and networks as a model to establish an Action Center for Biological Collections**.

A National Action Center for Biological Collections

- The biological collections community needs an **inclusive, integrated platform to strengthen the position of biological collections as a unified scientific infrastructure for the nation** over the next decade and beyond.
- **A national collections-focused action center dedicated to the support and use of biological collections could fill this need.**
- Its mission would focus on **all** biological collections and offer a collaborative platform to provide actionable and lasting solutions for the collection community at large.

Potential Coordinated Actions

- creating a national collections registry
- engaging new user communities, including small collections
- developing an evaluation plan and synthesizing quantitative and qualitative metrics
- establishing a workforce pipeline for personnel
- future-proofing financial models
- sharing best practices and standards for quality control
- building a shared cyberinfrastructure



National Decadal Survey

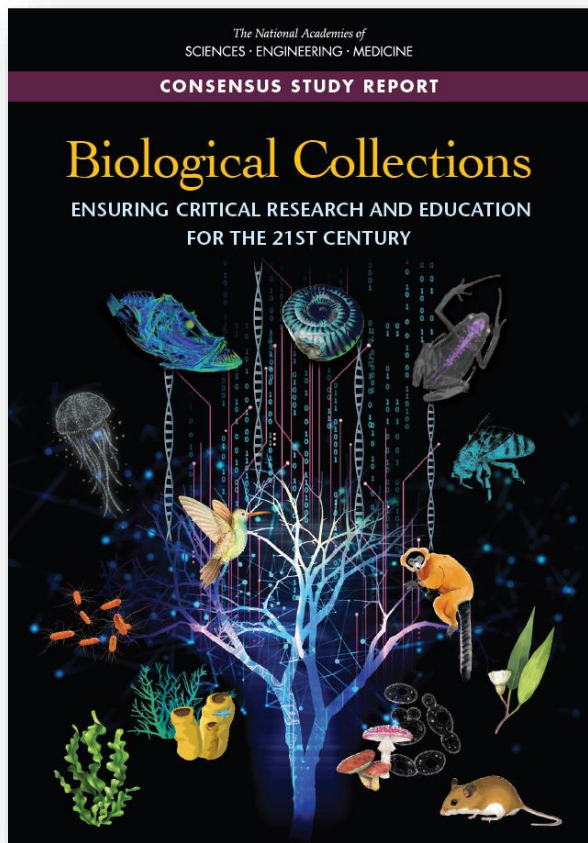
- Many scientific communities work together to set priorities for research and building infrastructure needs to accomplish those priorities.
- A biological collections-focused decadal survey would establish a set of priorities that could only be accomplished with a concerted effort of the community, rather than one biological collection.
- A decadal survey for the biological collections community needs to involve the natural history and living stocks collections communities.
- The collections community needs to make stronger connections with disciplines not traditionally associated with biological collections. Cross-directorate participation in a decadal survey would help to strengthen these connections.

A framework for collaboration and innovation is needed.

“We are drowning in information, while starving for wisdom. The world will henceforth be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely.”

E.O. Wilson, 1998

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QUESTIONS?



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