Grant Agreement Number: 777483 / **Acronym:** ICEDIG
Call: H2020-INFRADEV-2017-1 / **Type of Action:** RIA
Start Date: 01 Jan 2018 / **Duration:** 27 months
REFERENCES:
REPORT OF TASK T9.4
Work package **WP9** / Lead: **Naturalis**
Date: 20.01.2020
DOI: 10.5281/zenodo.3685634

ICEDIG.EU *Innovation and consolidation for large scale digitisation of natural heritage*

Humanities Researcher Synergies with Natural Science Collections and Archives

Task 9.4 Link with Cultural Heritage

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Erasmus Darwin's *The Botanic Garden* (1791)

Queen of the marsh, imperial Drosera treads
Rush-fringed banks, and moss-embroider'd beds;230
Redundant folds of glossy silk surround
Her slender waist, and trail upon the ground;
Five sister-nymphs collect with graceful ease,
Or spread the floating purple to the breeze;
And *five* fair youths with duteous love comply235
With each soft mandate of her moving eye.
As with sweet grace her snowy neck she bows,
A zone of diamonds trembles round her brows,
Bright shines the silver halo, as she turns;
And, as she steps, the living lustre burns.240

Drosera. l. 231. Sun-dew. Five males, five females. The leaves of this marsh-plant are purple, and have a fringe very unlike other vegetable productions. And, which is curious, at the point of every thread of this erect fringe stands a pellucid drop of mucilage, resembling a ducal coronet. This mucus is a secretion from certain glands, and like the viscous material round the flower-stalks of Silene (catchfly) prevents small insects from infesting the leaves. As the ear-wax in animals seems seems to be in part designed to prevent fleas and other insects from getting into their ears. See Silene. Mr. Wheatly ... observed these leaves to bend upwards, when an insect settled on them, like the leaves of the muscipula veneris, and pointing all their globules of mucus to the center, that they completely intangled and destroyed it. M. Broussonet, in the Mem. de l'Acad. des Sciences for the year 1784. p. 615. after having described the motion of the Dionæa, adds, that a similar appearance has been observed in the leaves of two species of Drosera.

POETIC BOTANY identifies an eighteenth-century movement in which botany became the subject of poetry. The relationship between art and science cultivated during this movement resulted in a rich trove of botanical knowledge, sumptuously presented in books, artworks, and gardens. (New York Botanic Garden, no date).

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1. Summary

Task 9.4, Link with Cultural Heritage, falls under WP9, Communication and Dissemination, an effort to identify external actors and ensure their input through effective communication, liaison, networking and dissemination. The task states that a multidisciplinary understanding is needed to effectively plan for the development of a global research infrastructure, thereby requiring that external actors and their potential synergies be identified. It further specifies that the inherent overlap of biodiversity collections with cultural heritage collections, especially in terms of accession books and field notebooks, must be made more explicit, and a roundtable of cultural heritage professionals is identified as a means to discuss these synergies. The scope of this task is limited to identifying synergies that humanities researchers derive from natural science collections, data and archives.

Fulfilling this objective was approached in two ways:

(1) surveying humanities researchers working at the interface of natural science collections and humanities regarding their use of natural science collections, data and archives, and

(2) discussing survey results with other (digital) humanities professionals, and representatives of national and pan-European humanities platforms and research infrastructures in a roundtable format.

Survey results and use cases demonstrated a need by this group of humanities researchers for using a natural science collections data and archive resource and preferably an integrated one, however, the survey was not statistically significant and did not represent the entire demographic.

Discussions at the roundtable covered many subjects. Most notably:

- Planning, organizational and policy concerns were expressed with respect to quantifying the demand for the data resource and having a means to assess whether it warrants investment, roles and responsibilities for driving the initiative and facilitating access and services, and the need to have a clearer understanding of the logistics of this specific landscape.
- A suggestion was made to make a feasible small start by finding common ground through early collaborations on open data standards ensuring future interoperability.

Final outcomes:

- It is the consensus of the roundtable that there is sufficient synergy between the domains to warrant further exploration but the framework and individual responsible to drive the effort forward remains undefined. Suggestions for a collaborative framework include FAIR, EOSC and Horizon Europe. If there is targeted funding, performing a large, comprehensive, statistically significant survey encompassing all synergies from both domains can serve as a basis for addressing planning, organizational and policy concerns. Otherwise collaborating on open data standards is a good start.
- Strategy must be discussed at higher management levels.

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- A key, post-roundtable appointment of a digital humanities specialist and national DARIAH representative to DiSSCo's Science Advisory Board was made. The appointee will be in a strategic position to provide humanities input as well as monitor potential collaborative opportunities.

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2. Introduction

In 2015, a recommendation was made to the European Commission's (EC) Commissioner for Research, Science and Innovation that a key priority for the EU's research and innovation policy should be to sponsor initiatives and venues that "foster, harness, and leverage collaborative interdisciplinarity" (Allmendinger 2015). The recommendation was part of a policy brief authored by a member of the EC's Research, innovation and science expert group (RISE), a high-level group of policy experts who advise the EC Commissioner for Research, Science and Innovation. The author's premise was based on the following: (1) scientific breakthroughs tend to take place at the border of or beyond traditional academic disciplines resulting in new interdisciplinary specialities that entail novel methods of using, producing and disseminating science, (2) there is a paradigm shift occurring in the public academic community from 'blue science' where relevance and application of cloistered research is not immediately apparent, to a more open, demand-driven, participatory paradigm that tackles real world problems and engages different audiences, research communities, stakeholders, and citizens, and (3) trans-, multi- and interdisciplinarity result in a more effective research organization committed to supporting and triggering innovation.

Closer to home, the DiSSCo Prepare Project Proposal contends that the proliferation of natural science research infrastructures and their diverse data mandates that infrastructures go farther than simply providing access to different classes of data. A "holistic approach is now required" where cross-linked information from the nano to the galactic "effectively underpins the entire research lifecycle and provides open access to mass and precise data" driving novel, integrative research (Hardisty et al. 2013). While this statement was written in the context of natural sciences, its premise is equally applicable to the integration of natural sciences and humanities, with socio-historical and temporal context completing the holistic picture.

With the value of interdisciplinarity having been established and advancements in technology and the e-science revolution enabling it, the question then is not whether digitally unifying science and humanities data resources is advisable or possible but whether it is practical and timely. Who are the people needing digital access to natural science collections and archive data resources . . . natural scientists supplementing collecting event data with critical detail, museum preparators needing an original drawing for accurate specimen reconstruction, art historians establishing the temporal and social context of a painting based on the species and age of its wood frame, archaeologists needing dates and collecting localities of ancient stone tools? Is the benefit sufficient to justify the cost? Is the volume of potential users large enough to warrant investment or is this a niche population? If the demand is small, are the needs of cross-domain researchers being satisfactorily met in other ways? Will the numbers of researchers using collections derived data and archive resources increase once integrated digital resources are provided? What kind of research is being done at this interface and how well do these research objectives align with the corporate mission or global priorities?

Unfortunately, the answers to many of these critical questions remain outside the scope of this task, but the inability to articulate and quantify appropriate answers does not preclude the practical

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imperative to begin discussions exploring future potential collaboration between the natural science collections and humanities domains. So it is from a broad long term planning perspective that this task was approached.

2.1 Objective

Potential synergies between the natural science and cultural heritage domains were initially considered from a multidirectional perspective and covered all institutional levels. That is, benefits natural science researchers and museum personnel would derive from links with cultural heritage, and non-research benefits derived by the humanities domain using natural science resources, such as using a collection object in an educational art exhibit, were initially considered. Due to time constraints, however, these synergies were excluded. Instead the task was refined to specifically focus on characterizing humanities researchers and their use of natural science collections, data and archives in a research capacity. However, in an effort to provide as broad a perspective as possible and support the premise that using an integrated collections data and archives resource may be beneficial to both domains, this report will also discuss relevant synergies of the natural science domain identified early in the investigation and documented in use cases, but focus primarily on humanities researchers in a research capacity.

2.2 Scope

Gaining the insight needed to fulfill task objectives was approached in two ways:

(1) surveying humanities researchers working at the interface of natural science collections and humanities regarding their use of natural science collections, data and archives, and

(2) discussing survey results with other (digital) humanities professionals, and representatives of national and pan-European humanities platforms and research infrastructures in a roundtable format.

The task was planned and executed on a short timeline. Over approximately two working months the Task Leader, except where noted, completed the following work objectives.

- A preliminary work plan was developed and reviewed with a task partner to identify potential roundtable candidates. This list underwent several subsequent iterations.
- Humanities researchers working at the interface of natural science collections were investigated and identified, and surveys for three different classes of respondents were developed, reviewed by task partners, and distributed over three weeks. Approximately 122 humanities researchers were solicited yielding about 34 responses (28%), and survey results were compiled and presented at the roundtable. Before the project scope was refined, 16 surveys were distributed to museum science researchers, collection managers, exhibition, education, and preparator personnel; eight were returned.

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- Personal interviews (Appendix 2) were conducted with one historian, a cultural heritage professional, two humanities platform representatives (BHL and Europeana], an art museum collections information and archives specialist/heritage professional, as well as four natural science museum personnel. Museum personnel were interviewed in the earlier context of considering multidirectional synergies.
- Potential roundtable participants (Appendix 3) were investigated and solicited, a roundtable was organized, and the agenda was developed and reviewed by task partners. Detailed roundtable notes were taken by task partners upon which a summary report was based. The roundtable summary report was reviewed by task partners and a final version was submitted as part of Deliverable 9.3, ICEDIG Stakeholder Roundtables (Gödderz 2020).

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3. Methodology

A preliminary work plan was developed to help conceptualize the target audience, shared resources, synergies and roundtable participants. Lists of Google-derived humanities disciplines, natural science museum collection data types, and library and archives resource types were compiled in a communal matrix to help visualize and evaluate which disciplines and resources had the most collaborative potential, and by extension, which online platforms and infrastructures should be included in the roundtable. From this initial analysis, it was judged that the anthropology, archaeology and history disciplines had the most collaborative potential and would make a good starting point for survey distribution, however, further investigation into the vast array of humanities platforms and infrastructures was required to refine roundtable participation.

3.1 Survey Methodology

An online Google survey was developed and distributed to humanities researchers at the natural science-humanities interface to characterize their potential use of natural science collections data and archives. The information gained from the survey was intended to inform the objectives and discussion of the roundtable and deliverable report. The following survey criteria applied.

- Almost all questions were multiple choice. Answers to two questions, 'desired functionality' and 'use case statements' were provided in free text.
- Respondents could select as many answers as applicable, although within Google Forms, multiple answers could not be prioritized.
- An 'other' category was always included to provide the option to supplement answers.
- All questions were voluntarily answered; none were required.
- The respondent was told to assume that the data resources in question were free, readily discoverable and digitally accessible.
- Survey (percent) results were calculated relative to the total number of individuals responding to the question, not the total number of answers.

The survey requested the following information.

Researcher
• Name • Institution • Capacity • Discipline • Research Interest

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General

Except for two questions pertaining to *integrated* data resources noted below, the following (abbreviated) questions were posed with respect to the researcher's *general use* of museum, university or botanic gardens science collection objects, data and archives.

- Preferred access via which domain?
- Most frequently used search terms.
- Download desired?
- Preferred download format.
- Most frequently used research infrastructures.
- Benefits of *integrated* digital access.
- Importance of *integrated* digital access.
- Desired functionality to increase probability or frequency of use.

Use Cases

Respondents were asked to provide use cases and to identify corresponding label data and archive resources utilized for each.

- Please identify the following types of natural science collections data you might use. This data is typically found on the object's label and reflects the collecting event.
- Please identify the following types of natural science archival resources you might use.
- In a few short sentences, please state your research objective and briefly describe how the resources check-marked in the two questions above would be used. For example, "IN ORDER TO provide temporal and social context to a painting I NEED TO identify the species of wood of the painting's frame USING the museum's wood reference collection and associated data."

Based on preliminary work plan assumptions, survey distribution began with historians and anthropologists and was expanded by means of referrals from colleagues and task team members, online research of museums and institutes hosting cross-domain disciplines, and via survey recipients forwarding the survey on to other colleagues working at the same interface. There was insufficient time to predetermine sample size and p-values. Response to the survey was acceptable considering most were distributed just before the Christmas holiday break and shortly thereafter and were returned under a tight timeline (122 humanities researcher surveys sent; 34 responses).

As mentioned, some surveys were initially distributed to *science* researchers and *museum personnel* before the task scope was refined. These surveys were also designed to capture their potential use of an integrated museum collections data and archive resource. These use cases, online use cases, and data from a 2018 Biodiversity Heritage Library (BHL) User Needs Analysis obtained from BHL's Outreach and Communications Manager will be referred to in the context of this report when appropriate. The BHL results are provided as an example of archive use by scientists and museum staff.

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3.2 Roundtable Methodology

The roundtable took place on 14 january 2020 from 11:30 - 17:30 at the Tulip Inn Leiden Centre, Leiden, the Netherlands. The official proceedings of the roundtable were preceded by a buffet lunch providing the opportunity for participants to get acquainted. In attendance were 13 representatives (Appendix 3) from the ICEDIG task, digital humanities, and the following global and pan-European online humanities (research) infrastructures.

- Biodiversity Heritage Library
- ARIADNEplus
- Europeana
- Digital Research Infrastructure for the Arts and Humanities (DARIAH)
- European Research Infrastructure for Heritage Science (E-RIHS).

Decisions regarding which humanities platforms and research infrastructures to include in the roundtable were influenced by several factors: (1) platforms and RIs representing disciplines with the most collaborative potential per the work plan, (2) three early interviews with historians and heritage professionals, (3) consultation with and referrals from task team members and (4) online research. BHL, Europeana and ARIADNEplus were selected based on these factors as well as their maturity as (research) infrastructures, broad content and user base, and potential use by the targeted group. The pan-European research infrastructures DARIAH (ERIC 2014) and E-RIHS (ESFRI Roadmap 2016) were chosen because of their status as European humanities research infrastructures, and wide array of networked resources, services and tools supporting (digital) humanities researchers and heritage professionals. These RIs are essential collaborative partners in any planning process related to humanities researcher needs.

Roundtable Objective

To define the digital requirements of cultural heritage researchers

working at the interface of science and humanities

that are needed to facilitate their use of museum, university, and botanic garden

natural science collections, data and associated archives.

The roundtable objective was pursued in three ways.

1. Establishing digital needs by means of:
   a. reviewing the survey results distributed to humanities researchers,
   b. listening to a use case from a digital humanities researcher,

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c. subsequent discussion between roundtable participants.

2. Understanding the content, function and services of, and potential for future collaboration with global and pan-European online humanities platforms and research infrastructures (BHL, Europeana, ARIADNEplus, DARIAH, and E-RIHS) by means of presentations.
3. Discussing and coming to a consensus about what the next steps should be.

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4. Results

4.1 Humanities Researcher Survey Results

Survey results were compiled and presented at the roundtable. Complete results are appended (Appendix 4) but essential findings are presented here in three parts (user characterization, user interface with a natural science research infrastructure, and use cases). Percent results were calculated based on a pool of 33 respondents.

4.1.1 User Characterization

- The respondent was primarily west European (80%) coming from universities and natural history museums (77%).
- The most represented disciplines were anthropologists (44%) and historians (41%).
- The most frequently used (research) infrastructures were BHL (64%) and Europeana (32%).
- 'Expanding research possibilities' (84%) was considered the primary benefit of digital access to an *integrated* natural science collections data and archive resource, and this access was considered 'most important' (44%) or 'important' (34%).

4.1.2 User Interface

- Preferred access to natural science collections data and archives was generally not divided along domain-specific lines, that is, 44% of the respondents chose access via *either* an online cultural heritage *or* natural science collections data portal.
- The most frequently used search terms in digitally accessing a natural science collections data resource were scientific name (55%) and locality (35%), and most respondents (55%) preferred to download search results in list format (.csv, .xlsx) indicating subsequent data manipulation.
- The respondents were further asked to identify desired functionality that would make them more likely to use natural science collections and archives. Answers to this question were returned in free text, and were thus highly variable and unquantifiable. Therefore, each desired functionality was mapped to a structured list of tangible achievable technical objectives needed to fulfill the wish, and the mapping was validated by DiSSCo's Data Architect, Sharif Islam. For example, a request for 'easy interfaces to linked open data' implied (1) design of a user friendly interface, (2) data mobilization, (3) natural science links with institutional archives, (4) natural science links with humanities RIs and (5) semantic annotation. The highest scoring structured categories representing desired functionality were 'data mobilization' and 'semantic annotation' at 62% each.
- Finally, the respondents were asked to provide use cases describing their use of natural science collection resources in their research, and to also identify the label data and archive resources used in each case (Appendix 4, pp. 48-50).

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- About 50% or more of the respondents used more than half of the label data, with collecting locality (92%) and scientific name (82%) being used the most. This result correlated with the respondents' preferred search terms.
- More significantly, about 50 - 90% of the respondents identified using *all* listed museum archive resources with the exception of audio and video. Field notebooks and diaries (90%), collection catalogues (84%) and accession books (78%) topped the list.

4.1.3 Use Cases

Approximately 43 use cases were grouped according to the similarity of their objectives, and one use case per category is provided here for consideration.

1. Category: *Historic reconstruction of persons, objects, collections or events* (Appendix 4, p. 52)

   This use case involves a historian investigating an object's or subject's history, that is, its provenance and circumstances of the collecting event. To achieve that, all available sources of textual and graphic information including (publications, correspondence, notes, audio and video) are needed. The *inferred*[1] resource meeting these needs is an integrated humanities and natural science research infrastructure including associated archives and semantically linked data.

2. Category: *Historic reconstruction and human influence* (Appendix 4, p. 53)

   This use case involves an anthropologist/archaeologist investigating long-term human-environment (human-animal) interactions wanting to understand the human impact on the use and spatial, temporal and cultural distribution of a species. To achieve this, the researcher must quantify the species' presence across sites, create chronological context, and compare morphology across individuals. The *inferred* resource meeting these needs is an integrated humanities and natural science research infrastructure including associated archives and semantically linked data.

3. Category: *Reference: Identification of species or species comparisons* (Appendix 4, p. 54)

   This use case involves an anthropologist / ethnoecologist needing to determine the species used in the construction of organic ethnographic objects. In order to do this (it is *inferred* that), one must use a reference collection of objects, online resources and associated archives and/or expertise to identify the species. These needs could be met through the use of an integrated humanities and natural science research infrastructure including associated archives and semantically linked data (inferred).

   The anthropologist's second use case involves the need to compare similar objects between collections. In order to do this (it is *inferred* that), one must have physical or online access to similar collections including data and photos. The need could be fulfilled by the use of an

[1] The use case asked for a free text response that was often left unanswered, or cryptically or partially answered. Therefore as needed, the user's requirement to meet their need was 'inferred' based on the stated objective and/or identification of the label data and archive resources used. In the use case tables in Appendix 5, inferred text is preceded with an 'I" in parentheses, **(I)**.

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integrated humanities and natural science research infrastructure including associated archives and semantically linked data (inferred).

4. Category: *Scientific Inquiry* (Appendix 4, p. 55)

   The final use case involves an anthropologist / archaeologist / paleontologist studying human evolution who needs to use fossil bones and lithic collections in museum and university collections. In order to do this, he must access collection catalogues, digital pictures and drawings and any other useful information such as diaries, notes and letters. The *inferred* resource meeting these needs is an integrated humanities and natural science research infrastructure including associated archives and semantically linked data.

The results of the survey clearly demonstrate a need by humanities researchers working at the interface of natural science and humanities for the use of an *integrated* humanities and natural science collections and archives data resource. This solution was primarily *inferred* based on the user's stated objectives and/or the identified label data and archive resources used, and validated by DiSSCo's data architect, Sharif Islam. There were a handful of researchers having slightly more specific needs such as georeferenced localities, mapping capability, aDNA and isotopic analysis, but these were the exception.

4.2 Roundtable Results

4.2.1 Digital Needs of Humanities Researchers, Andreas Weber, University of Twente, The Netherlands

Andreas Weber is an assistant professor in the department of Science, Technology and Policy Studies at the University of Twente, NL, specializing in the relationship between science, technology and culture from a long-term and global perspective including the application of computational technologies.

A. Weber introduced his recent work with the *Making Sense of Illustrated Handwritten Archives* project, an effort to interpret the rich collection of 17,000 handwritten pages of notes and illustrations from the Dutch Natural Science Commission documenting the scientific exploration of the Indonesian Archipelago (1820- 1850), using a state-of-the-art machine learning handwriting system. Often considered too historical for biologists, and too biological for historians, this resource was never fully studied or interlinked making it difficult to find the correct combination of specimen, illustration and field notes. So the objective of the project was to create a searchable digital repository of the archive for historians, biologists and the general public.

Challenges faced in the text recognition effort included the use of multiple languages, intertwined visual and textual elements, and different authors and styles on the same page. Other project challenges included taxonomic (nomenclatural) uncertainty when the queried scientific name did not match the text, and the use by historians of antiquated search terms.

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The semantically annotated project prototype makes a good starting point to understand humanities researcher needs with respect to their use of a natural science data resource. While linkages between specimens, field notes, drawings, and publications are important to both the science and humanities domains, humanities scholars are more interested in *how* an item has been collected or the political context of the collecting event. Weber made the following observations and suggestions.

- Sufficient links between specimens, literature, field notes and diaries, and drawings are weak or missing. Specimen links to textual and visual archives are a treasure trove for cultural heritage researchers.
- Data portals of natural science collections are often a difficult starting point because search terms, e.g., species names, persons, dates, are often too narrow to yield satisfactory results of more broadly asked questions like "Which bat species were collected and drawn in Java from 1820-1833?" For this question, an advanced search combining Order, collecting date and locality, paired with an additional option to search on 'hand-written' or 'hand-drawn' category would have been helpful.
- Optimize data discovery: Free text searches, searches for domain-specific parameters (e.g., search options for handwritten, hand-drawn water-color, print, etc.) would be helpful. In annotation, think about socio-historical context, e.g., many specimens collected by the Global North come from the Global South due to deeply linked histories of colonialism and imperialism. Humanities researchers would prefer to have an extensive list of searchable metadata, but keep the fields as broad as possible.
- Seamless taxonomic mapping of queried species name to the appropriate specimen and its associated data would be very helpful.
- Cultural heritage researchers will find their way as soon as natural history collections are digitally searchable in a convenient, attractive way.

4.2.2 Humanities platforms and research infrastructures, Jane Smith, BHL, Members' Council, Vice-Chair

(The following is an edited version. For full summary text, see *Stakeholder Roundtables*, Gödderz 2020, p.56.)

BHL is a global consortium of natural history, botanical and research libraries that collaboratively provides open and free access to the world's largest digital library of biodiversity literature and archives (56 million pages and over 150,000 illustrations viaFlickr). Access is facilitated through digitization, data integration, linking library and archives to specimens, and user engagement. BHL content underpins the work of researchers around the world by providing species data and descriptions, distribution maps, scientific observations and illustrations, geological and climatic records, history of scientific discovery, information on extinct species, and ecosystem profiles. BHL collaborators share a common digitization strategy regarding standards and practices including copyright, however, open access is actively encouraged. BHL contributes content to: GBIF, CETAF, EOL, Europeana, TDWG, Digital Public Libraries of America, ICSTI, and works with the international biodiversity informatics community to facilitate greater access, interoperability, and reuse of

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content. Through the Global Names Recognition and Discovery (GNRD) service, BHL indexes taxonomic names, allowing researchers to locate publications about specific taxa. BHL content will remain natural history focused but its scope will broaden to support use by the arts and humanities, other research disciplines and the public. BHL has over seven million users from 243 countries and territories.

4.2.3 Humanities platforms and research infrastructures, Franco Niccolucci, ARIADNEplus, Project Director

(The following is an edited version. For full summary text, see *Stakeholder Roundtables*, Gödderz 2020, p.57.)

Franco Niccolucci is currently coordinator of ARIADNEplus, a research infrastructure of archaeological data, and the director of VAST-LAB, a research and development lab involved in the definition and implementation of new technologies for cultural heritage.

ARIADNEplus is an EC H2020 research infrastructure whose mandate is to iteratively integrate European (+ Israel, Argentina, Japan, USA) archaeological datasets, first with metadata and then by item. The two million datasets currently available are primarily derived from emergency excavations that are catalogued in a searchable registry including images, drawings, maps, and videos. The registry includes all large, mostly national data repositories. Cloud services are provided to ARIADNEplus' 11,000 users and its standardized vocabulary is multilingual. ARIADNEplus semantics are based on an international cultural heritage conceptual reference model, and the registry is searchable by where-when-what and keywords. Cloud-based processing services will be implemented in 2021 including a multilingual text mining tool that recognizes names, entities and their key relationships. ARIADNEplus ensures data quality through FAIRification and repository certification.

4.2.4 Humanities platforms and research infrastructures, Marco de Niet, Europeana Pro, Europeana Network Association (ENA) Management Board Chair

(The following is an edited version. For full summary text, see *Stakeholder Roundtables*, Gödderz 2020, p.58.)

Marco de Niet is responsible for all physical and digital services provided by Leiden University's library. He has been involved with Europeana from its inception including formative collaborations in previous employment at the Dutch national library.

Europeana brings together digitized content from museums, galleries, libraries and archives across Europe to make it easier for people to use cultural heritage for work, learning or pleasure, and has a 5-year strategy to support the digital transformation of Europe's cultural heritage sector. Europeana's many domains are divided into topics and themes and surprisingly, its largest collection is its natural history collection. The diversity ensures that Europeana finds common ground between its institutions, however, it makes developing a data model more challenging. Its licensing framework requires all metadata to be published as public domain (CC0), and all digital objects must carry a copyright status. Europeana, in its commitment to quality, has chosen to delete over 20% of

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its current content because it does not meet established criteria. Its organizational structure is functionally partitioned to ensure continuity with management changes.

M. de Niet discussed Europeana's Impact Assessment Playbook, a guide developed to take museums, libraries, archives and galleries through the first phase of an impact assessment, and suggested it could be beneficial to use Playbook tools to assess the value of integrating natural science and cultural heritage collections.

He then discussed the results of Europeana's recent analysis of researcher needs compiled from 31 humanities infrastructure reports and an october 2019 survey (377 respondents from 37 countries).

Among the most relevant findings were:

- Tools, content and research infrastructures should cater to the increasingly multi- and interdisciplinary character of research.
- Partnerships and coordination actions should be amplified to maximize the impact of DHC and co-create new innovative services as part of the Open Science Movement.
- Promote FAIRness of data through guidelines and training.

4.2.5 Humanities platforms and research infrastructures, Tatja Scholte, E-RIHS NL, Dutch National Coordinator

(The following is an edited version. For full summary text, see *Stakeholder Roundtables*, Gödderz 2020, p.59.)

Tatja Scholte is the Dutch National Coordinator for the European Research Infrastructure for Heritage Science (E-RIHS) and is currently programme manager at the Dutch Cultural Heritage Agency (Rijksdienst Cultureel Erfgoed).

E-RIHS (ESFRI roadmap 2016) is a European research infrastructure of heritage science supporting interpretation, preservation, documentation and management of cultural heritage, and is working towards a vision of becoming a *global* distributed research infrastructure. Its mission is to deliver integrated access to expertise, data and technologies through a standardized approach, and to cohesively integrate European facilities within the global heritage science community. Its four domains of heritage science are: collections of art material, cultural and natural heritage, archaeology, built heritage, and archives.

E-RIHS will foster interdisciplinary innovation by interfacing humanities research with science, technology, engineering and mathematics (STEM) and communications technologies (ICT), and will provide access services through four integrated platforms:

- Virtual access to scientific data concerning tangible heritage
- Access to large-scale and medium-scale fixed facilities
- Access to advanced mobile analytical instrumentation for non-invasive measurements
- Access to archives of specialized knowledge and organized scientific information.

4.2.6 Humanities platforms and research infrastructures, Sally Chambers, DARIAH-EU, National Coordinators Committee Chair

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(The following is an edited version. For full summary text, see *Stakeholder Roundtables*, Gödderz 2020, p.59.)

Sally Chambers is DARIAH-BE's national coordinator and the Digital Humanities Research Coordinator at Ghent University, BE. Sally was Secretary-General for the DARIAH-EU Coordination Office (2011-2015) and prior to that, focused on interoperability, metadata and technical project coordination for the European Library.

- DARIAH is a Digital Research Infrastructure for the Arts and Humanities.
- Enables excellent research in the Arts and Humanities by exchanging and sustaining tools, services, data and knowledge from its member countries and facilitating the wide uptake of digital methods.

Key elements of DARIAH's latest strategic plan (2019).

- Creating: Build a Marketplace to facilitate fluid exchange of tools, services, data and knowledge.
- Transforming: Build access to education and training.
- Connecting: Build working groups, hubs and other forms of transnational and transdisciplinary organization enabling researchers to work together.
- Complementing: Build bridges between research policy and communities of practice.

DARIAH's member countries contribute the following activities and services: coordination, access, expertise, interoperability, hosting content, tools and software, training, summer schools, and events. 'The Marketplace' consists of high-quality locally produced tools shared internationally. DARIAH provides training and education services and resources, and facilitates working groups and interdisciplinary collaboration including with ICEDIG and DiSSCo. The social sciences and humanities contribution to the European Open Science Cloud (EOSC) is called SSHOC (the Social Sciences and Humanities Open Cloud), and is dedicated to FAIR principles.

Potential synergies between digital humanities and the cultural and natural heritage sectors could manifest in the shared trend toward Open Science and in collaborative training and education related to digital technologies. Data level access, i.e., access to digitized content in closed digital silos, is however, one of the remaining challenges.

4.3 Biodiversity Heritage Library (BHL) User Needs Analysis

(For a full description of BHL, see 4.2.2 *Humanities platforms and research infrastructures*, *Jane Smith, BHL* above.)

The Biodiversity Heritage Library (2018) conducted a user needs analysis designed to inform BHL development that also identified its user base, frequency and type of use. Partial results of the survey, obtained from BHL's Communications and Outreach Manager, are presented here to

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characterize the use of a global scientific archival resource by the science community. The survey had 606 respondents providing a 95% confidence level and 4% margin of error.

Disciplines: When asked, almost half of 581 respondents (48%) described their role as a scientist or taxonomist, 5% identified as collection managers and 3% as museum curators. Approximately 45% identified as citizen scientists, historians, librarians, illustrators, students, educators, publishers, and government officials. So more than 55% of the user base of the world's largest source of online biodiversity literature and archives identified as scientists or museum professionals.

Use: Another relevant outcome was that the two top uses of BHL content were to cite or identify a species (55%) and to write a scholarly article (51%). Another 27% used BHL for 'other' purposes but the majority of these other uses aligned closely with the two top uses of professional scientific and taxonomic work such as compiling bibliographies on species, utilizing the original description of a species, writing other scholarly works, and overall research.

Archives: When asked whether they used BHL's *unpublished* archival/manuscript content (e.g., correspondence, field notes, diaries), 22% responded 'yes'. Of those responding 'yes', 38% self-identified as a scientist/taxonomist and 13% as a historian, and were looking for general taxonomic and species information, original descriptions, and occurrence data.

Images: When asked whether they used BHL's illustrations/images, a majority (72%) responded 'yes'. Of those responding yes, 50% identified as scientist/taxonomist. The images were used for identifying species, species descriptions, reference, citation, and comparison, and for linking to other databases. Many respondents mentioned using images in lecture slides, publications, presentations, blogs, and social media.

Use of other RIs: When asked what other data sources were used, 55% indicated GBIF, and 48% indicated Encyclopedia of Life, GenBank 39%, Biostor 25%, and iDigBio 23%.

BHL's User Blog is a collection of individual professional stories recounting how its content is used and by whom.

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5. Discussion

Before embarking on discussions, it is relevant to note here that roundtable participants concluded their meeting by expressing a preference to continue the conversation exploring potential synergies that humanities researchers receive from collections derived data. Discussions below are therefore framed with that future potential in mind.

5.1 Survey Discussion

5.1.1 Limitations

The humanities researcher survey was not designed to be statistically significant but was intended to identify potential synergies. Furthermore, completing the survey was voluntary and one means of survey distribution was for recipients to forward it on to colleagues working at a similar natural science / humanities interface. So even though the results demonstrate a need for digital access to natural science collections data and archives, this outcome is not without sampling error. That is, the conducted survey did not cover a statistically significant number of cross-domain humanities researchers and the results therefore reflect the preferences of the surveyed population and not the demographic as a whole. This limitation should be kept in mind as it will not be referred to again in qualifying survey results. If quantifying demand is essential for prioritization and funding, a broader, statistically significant survey covering a range of humanities *and* science disciplines as well as auxiliary uses (collection managers, museum laboratories, non-natural science museums) is suggested.

This survey focused on the use of natural science collections, data and archives by humanities researchers and resulted in some important points to consider when initiating future collaborations.

5.1.2 Need

- SYNERGIES: Use case scenarios (Appendix 5) collectively establish that the natural science data needs of cross-domain humanities researchers could be optimally fulfilled with an integrated natural science collections and archives data resource. The respondents highly prioritized digital access to and were potentially heavy users of this data resource, as 50-90% of the respondents identified a preference for using almost *all* of the listed archive resources (except audio and video), *most* of the object's label data (collecting locality, scientific name, collection date, collector), and scientific fotos. Field notebooks / diaries (90%), collection catalogues (84%), and accession books (78%) were the most frequently used archive resources (Appendix 4, pp. 49-50) and underscores the importance of these specific resources in cross-domain humanities research. This outcome is anecdotally reinforced in the *natural science* domain. Six of eight museum researchers and support staff also prioritized field notebooks, collection catalogues, and accession books in their use cases for differing reasons,

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i.e., museum scientists supplementing occurrence data with essential detail[2], collection managers facilitating digitization[3], museum education enriching online educational activities[4] and museum preparators using an original drawing for accurate specimen reconstruction[5]. Mobilizing, linking, and semantically annotating collection objects and associated archives should therefore be a first consideration to accommodate the needs of both domains.

- NEED FOR ACCESSIBLE LINKED DATA: The respondents were asked to identify desired functionality that would make them more likely to use natural science collections and archives or use them more frequently. Their free text responses were mapped to structured, achievable objectives. For example, a request for 'easy interfaces to linked open data' was mapped to the following objectives (1) design of a user friendly interface, (2) data mobilization, (3) collection data linked to institutional archives, (4) collection data linked with humanities RIs, and (5) semantic annotation. Two mapped categories, 'data mobilization' and 'semantic annotation', topped the desired functionality list at 62% each. This result not only implied an essential need for accessible linked data but also lends credence to the axiom 'if you build it they will come', as respondents were asked to identify functionality that would make them *more likely to use or increase their frequency of use* of a natural science data resource (Appendix 4, pp. 46-47).
- EXPANDS RESEARCH POSSIBILITIES: In addition to the practical economies gained with access to an integrated natural science collections and archives resource (saves time, convenient, saves money), 84% of the respondents identified 'expands research possibilities' as the primary benefit of *integrated* access, and it is this enlargement of possibilities that fosters interdisciplinarity and innovation. Perhaps in recognition of this potential, 78% identified integrated access as being most important or important.

[2] The following footnotes represent anecdotal evidence from eight surveys initially distributed to *science* researchers and *museum personnel* before the task scope was refined and/or from online research (Appendix 5). Per a **museum scientist**, "We have expedition collections which were collected, e.g., in early 20th century, with samples well documented in terms of species, localities, but no further context. If this information could be linked to what is available in the archives, e.g., maps and field notebooks, we would get a much better picture of the purpose of some of these trips." The potential importance of mobilizing archives to the natural science community is more powerfully illustrated by the recent publication of a pamphlet formerly lost to science because of its (at the time) *shocking* subject matter. The pamphlet (Russell, Sladen & Ainley 2012), based on direct observations of Adélie penguins by the medical officer and biologist in Captain Scott's 1910-13 Antarctic expedition, documents the penguins' "sexual depravity" but was too shocking to publish and widely distribute at the time. Only recently was the pamphlet unearthed and published by a curator at NHM London. Adélie penguins are indicator species and the newly published literature and revised scientific understanding of their reproductive behavior are important to climate change research (McKie 2012).

[3] Anecdotal evidence: Per a vertebrate **collection manager**, digitization of "accession books, collection catalogues, field notebooks / diaries, and correspondence contain basic information about a lot of specimens that can be used in registration. We are working towards a one [database] record per specimen vision". A library and archives collection manager also values digitized (scanned) original documents adding that it allows her to "run [digitization] projects via online communities, volunteers, crowdsourcing, if they have access to these scans as well as the specimen database".

[4] Anecdotal evidence: Per a museum **head for educational development** "We could use this [field notebooks / diaries, correspondence, maps, drawings, photos, paintings, audio, video] for context rich, digital educational activities in which we not only focus on biological concepts, but also on the cultural historic aspect of our collection and research. This fits well with our goals to enhance science literacy."

[5] Anecdotal evidence: A Smithsonian paleontologist and **museum fossil preparator** used digitized detailed original descriptions and illustrations of a unique dinosaur to re-prepare the specimen (Pinsdorf 2019).

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5.1.3 Collaborative Potential

- DISCIPLINES: Future exploratory efforts should include historians and/or anthropologists. These were the survey's most well represented disciplines, probably due to the natural gravitation of the survey to disciplines most likely to use the resources [19/33 (58%) of the respondents were not originally solicited, i.e., the survey was forwarded to them by a colleague]. The preponderance of historian and anthropologist respondents here represents disciplines with collaborative potential, not necessarily demand, as sampling error is a factor. Preliminary collaborative investigations could be initiated using input from historians studying the history of science or science collections, anthropologists (ethnoecologists, ethnobotanists, physical anthropology), or archaeologists.
- RESEARCH INFRASTRUCTURES: The most frequently used research infrastructure was BHL (64%) by a factor of two relative to the next RI, Europeana (frequency undefined). Although BHL considers collaboration with its core user base of scientists and taxonomists to be critical, it is also expanding to include a wider audience in other research disciplines and the public. Still, the predominant use of a biodiversity library by humanities researchers was slightly surprising, although it makes sense if one considers that cross-domain humanities researchers are looking for literature that elaborates on basic collecting event data and provides historical or social context. As an example, searching in BHL for 'humpback whale' displays the following results, 'Whale Hunting with Gun and Camera', 'Newfoundland and Its Untrodden Ways', 'Memories of the Cuban Society of Natural History', 'American Fish Culture Meeting Proceedings', etc., in addition to relevant biodiversity texts. These titles are of undeniable relevance to those studying history, culture, and relationships in the natural sciences realm. However as evidenced by the survey use cases, humanities researcher synergies extend beyond literature. They also use *scientific* data and BHL helps form a holistic picture by filling socio-historic information gaps and in some cases, reunifying literature with its object.

  The finding that humanities researchers primarily use BHL is important when considering collaborative potential with other heritage infrastructures, as it indicates that BHL successfully bridges the natural science and humanities divide by providing literature and archive resources essential to both domains. And that is a fortuitous coincidence when considering that the interdisciplinary potential of both research communities is fostered by BHL's cross-domain one-stop-shop of biodiversity literature, correspondence, field notes, diaries and illustrations. BHL should therefore be a first consideration when exploring collaborative potential with research infrastructures not only because of its potentially frequent use by humanities researchers and proven use by scientists and taxonomists (see following 5.4 BHL User Needs Survey Discussion), but also because its mix of content provides a ready-made laboratory for interdisciplinarity and innovation and thus provides a bird's eye view of the mechanisms behind these processes.

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5.1.4 Other Considerations

- SEMANTIC ANNOTATION: The use case scenarios of the humanities researchers were varied and some quite unique, but could primarily be grouped in four broader thematic categories:
  - historic reconstruction of persons, objects, collections or events,
  - historic reconstruction and human influence,
  - use of natural science collections, data, and archives for reference (identifications and comparisons),
  - science based studies (biologic, paleontologic).

  The first two bulleted categories reflect a traditional perspective and approach in humanities research, while the last two are more consistent with a natural scientist's typical use of data resources and will not be included in this discussion. The first two use categories reinforce the need to consider context and relationships in semantic annotation for humanities researchers, e.g., identifying all objects of a particular collector, collection, collecting event, artist, exhibition or expedition, identifying the political or cultural zeitgeist, or identifying geologic age, stratigraphy, etc. The most essential annotation parameters can perhaps be determined by means of a broader survey or workshop.
- ACCESS TO DATA RESOURCE: Access to an integrated natural science data resource was not domain-specific with 44% of the respondents choosing access via either the natural science (e.g., GBIF) or humanities domains (e.g., BHL, Europeana, ARIADNEplus). The inference here is that most researchers were comfortable using both domains and that they should be linked in a way that facilitates discoverability. However, although there was no explicit preference for access via one domain or another, it's reasonable to expect that providing a customized humanities user environment and the tools and services enabling access to and use of natural science collections, should fall under the purview of the humanities domain.

5.2 RT Discussion: Definition and Prioritization of Needs

Roundtable representation by the humanities domain was generally satisfactory, however humanities researchers were underrepresented owing to short project timelines compounded by the holidays. Their input was potentially important because their first-hand knowledge and experience would have substantively enriched the conversation, however, it is doubtful whether it would have significantly altered the final conclusions.

The first round of discussions at the roundtable was intended to better define and prioritize humanities researcher needs, however, the discussion began with more fundamental themes and questions regarding the size of the demand and cost-benefit of cross-domain integration. Although

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these concerns were entirely relevant, addressing them fell outside the scope of the task. The discussion was facilitated by A. Casino and the following points were made.

5.2.1 Need

- Need: Linking natural and cultural heritage data resources is key to an overall picture of describing collections. Identifying humanities researcher needs will inform DiSSCo planning and development and has the potential to similarly inform the development of other research infrastructures, e.g. BHL content is growing in cultural richness and wants to support research across disciplines.
- Need, chicken-egg: The demand for an integrated natural science and humanities data resource is presumed to be a niche market now but could expand as domains are integrated and services are provided.
- Need, pluck low hanging fruit: What are the respective domain objectives and what is already available to meet those needs? What is expected of the research communities, and what do researchers want to do with integrated resources? It seems prudent to start by undertaking activities that are doable and useful, to grab the so-called 'low hanging fruit'.

5.2.2 Concerns

- Timing: Are discussions regarding the potential collaboration of natural and cultural heritage domains premature? Most research infrastructures are developmentally emerging themselves.
- Cost / Benefit: Is the demand for integrating natural science data resources with the humanities domain and the precedence that it could assume over core mission objectives sufficient to justify the investment? And how can the demand be quantified to justify inclusion?
- Better understanding needed: Currently there are gaps in terms of (1) information availability and thus what gets mobilized, (2) interlinking that information, and (3) services provided to make the data available and actionable. Stakeholders and services change with this value chain so some services may need to be allocated outside of the cultural and humanities research infrastructures. Need better understanding of the landscape.

5.2.3 Development

- Collaboration: While both sides agree that collaboration is required to formulate a long term holistic response to global challenges that meets the needs of both domains, it is unclear which domain is most appropriate to initiate and drive the collaboration forward. Because the two domains differ in terms of language, methodology and terminology, E-RIHS or DARIAH might be the appropriate intermediary, however, E-RIHS states that it is not currently prepared to facilitate this level of discussion. Possible opportunities for

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collaboration could arise under the interdisciplinary emphasis of Horizon Europe or in relation to global data accessibility of the European Open Science Cloud.

- Open data standards and quality assurance: We should not worry about interlinking infrastructures at this point, however, collaborating early on (meta)data standards and interoperability will ensure the possibility of establishing needed links in the future. Developing standards will require a long-term community investment. Rather than starting with ontologies, collaboration can be initiated by first finding common ground between the two diverse domains. However, DiSSCo needs to ensure data quality in addition to agreeing upon standards.
- Humanities researcher perspective: Humanities researchers are looking for context. They are not focused on individual specimens or objects but are interested in reconstructing the *relationships* of objects in a social or historical context. In an example from a survey use case, the research objective was to determine an object's provenance, that is, how it had moved through owners and locations. This information is compiled by natural science institutions as part of their collection management system, but is not relevant to natural science research and thus not included in DiSSCo. Whether this type of information should be included in DiSSCo to accommodate the humanities domain requires further investigation of demand, cost and benefit.
- Scientific names: Although the user survey identifies scientific name as being the most frequently used search term, using it in a query can yield uncertain results for the taxonomically uninitiated when the queried name doesn't correspond with search results. Search results may reflect an old name, an invalid name, a synonym or homonym, etc., requiring further taxonomic investigation. In this regard, it is incumbent upon the natural science research infrastructure to provide a seamless user experience and user friendly, reliable results. However, using scientific names as an anchor to link data remains problematic due to its inherent variability and instability.

5.3 RT Discussion: Interface and Coordination

The discussion objective was to plan for any policy, procedural or technological considerations or action items resulting from the overlap of humanities researcher needs with the tools, services and infrastructure designed to support them.

D. Koureas began by suggesting that these preliminary discussions could use better follow-up and continuity. In similar situations the tendency has been to put them on a shelf without further intervention. He further observed that while Europeana is not really a vehicle for natural science research, its volume and diversity of data types was worth building upon. The question remains . . . how? Thematic data sets of Europeana could be a vehicle for integration with natural science, however, this would require that research infrastructures provide usable data for Europeana, and it was further suggested that EOSC might be the means for that. The flaw in this proposal, however, is

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that the cluster projects working towards FAIR data standards and the EOSC are siloed in thematic areas whose interactions are driven by thematic labeling and not need.

Is there a next step in the potential for collaboration between the natural science collections and humanities domains or is this a one-off discussion? What is the mechanism to continue discussions? Suggestions and observations were:

- FAIR could be common ground to continue.
- The effort requires someone driving the conversation, and also strategic higher level executive participation.
- Interested individuals could join the research community to monitor status.
- DiSSCo is very receptive to having more input from humanities experts but the desire must be reciprocated by the humanities community. DiSSCo will be provided with a list of potential consultants.
- The conversation has to continue at different levels: strategic, via DARIAH, DiSSCo General Assembly, and with national coordinators. The history of science or history of natural science could be a good entrance point.

5.4 BHL User Needs Analysis, Discussion

In this report, BHL user needs survey results are included in the context of identifying synergies natural scientists have with archival data resources, and were obtained from BHL before the task scope was refined. In an effort to provide as broad a perspective as possible and support the premise that using an integrated collections data and archives resource may be beneficial to both domains, relevant BHL survey results are included. Results pertaining to improvements for BHL's future development were excluded.

Overall, the survey (606 respondents, 95% confidence, 4% error) establishes that as a group, scientists, taxonomists, historians, museum curators and collection managers make-up a majority (60%) of BHL's user base, and that BHL content is primarily used in a research capacity to cite/identify species, write scholarly articles, compile species bibliographies, and reference species descriptions. Users are not only using published content but scientists/taxonomists (8%) and historians (3%) are also using BHL's *unpublished* archives (correspondence, field notes, diaries) looking for taxonomic and species information, original description and occurrence data. Images are used by more than a third of the scientists looking for species ID, descriptions, reference, citations, comparisons and linking. Moreover, a host of other science research infrastructures, GBIF, EOL, GenBank, Biostor, and iDigBio, are used. All of these survey results firmly establish that BHL is a library and archive resource used predominantly by scientists, other researchers, and museum personnel to perform research or use its content in a scientific capacity.

These findings serve as a useful parallel providing insight into the *potential use of natural science museum archive resources* by the same demographic. Arguably, natural science museum archives could prove to be more highly utilized by both the natural science and humanities domains because

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of its richer concentration of archives that specifically reflects the museum's collection which in turn, reflects the museum's history. That is, museum archives contain information and illustrations specific to an individual specimen, collection, collecting event, collector, accession, exhibition or expedition that are useful to scientists interested in individual specimens or collections, historians looking for broader contextualized relationships germane to museum objects, people or events, as well as a host of museum staff using the resource in their work (5.1 Survey Discussion/Need/Synergies/ footnotes, and use cases, Appendix 5). Facilitating digital access to museum collections data and archives could prove to be mutually beneficial to both the humanities and natural science domains in research, science and educational capacities.

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6. Conclusions

Examining potential synergies between the natural science collections and humanities domains is an inevitable outgrowth of the trend towards holistic interdisciplinary research and the indisputable value it adds in terms of cultivating innovation through cross-fertilization of research outlooks, routines and paradigms and expanding research possibilities. So the Task objective to identify potential synergies humanities researchers have with natural science collections, data and archives is the first step towards realizing this potential. Potential synergies were identified by means of surveying humanities researchers working at the interface of natural science and humanities to characterize how they use natural science collections, data and archives. These results were used to inform a subsequent roundtable discussion attended by representatives of ICEDIG, (digital) humanities, humanities platforms and research infrastructures.

The survey use cases establish a need by cross-domain humanities researchers for using natural science collections, data and archives, and optimally, an *integrated* resource. Due to the Task's compressed time frame the survey did not establish whether the need was statistically representative of this demographic, or quantify the size of the demand relative to other core mission objectives. This information may be critical when prioritizing or considering funding but was not essential to the initial roundtable dialogue.

The final outcome of the roundtable was that the synergy between the two domains was significant enough to warrant further exploration, and that the conversation should continue, although the means to this end remains undetermined. So although survey results revealed a wealth of information regarding researcher needs and preferences, and highly relevant planning, organizational and policy concerns were expressed in the roundtable, all of these topics were in the end premature and will not be discussed here as their essential points have been earlier documented. It is from the perspective of finding or creating opportunities for future exploratory collaborations that the next section has been written.

6.1 Findings and Next Steps

6.1.1 Coxswain, Strategy, Framework

- One of the domains must initiate and drive the collaboration forward. Sally Chambers, a digital humanities research coordinator for Ghent University (BE), Belgian DARIAH coordinator, and a roundtable participant has been appointed to DiSSCo's Scientific Advisory Board. She is in a strategic position to provide a humanities voice in a chorus of natural scientists and can also monitor potential collaborative opportunities.
- Strategy must be discussed at higher executive levels (DARIAH, E-RIHS, and DiSSCo's General Assembly).

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- There must be an organizational and financial framework for collaboration. Possible opportunities could arise under the interdisciplinary emphasis of Horizon Europe, or in relation to global data accessibility of the European Open Science Cloud or FAIR data.

6.1.2 And Then?

- The *scientific approach* is to objectively evaluate all multidirectional synergies that an integrated natural science and archive resource could facilitate, and quantify demand to inform prioritization and funding. For this, a broad, statistically significant study is recommended. This study would not only cover humanities and natural science researcher synergies but also identify science and educational benefits derived by museum collection managers, preparators, exhibition and education personnel and even other museums. If properly designed, the study's outcome could quantify relative domain benefits and thus provide conceptual clarity regarding organizational and funding roles and responsibilities of each. Study results could also serve as a basis for: planning data mobilization (assuming there's mobilization readiness status via Join the Dots?[6]), collaborating on (meta)data standards, and standardizing terminology and methodology. This approach presumes an organizational framework and targeted funding.
- The *humanities approach* is a gradual, iterative process that grows organically using small, perhaps concurrent vehicles, exploiting existing frameworks. A feasible first step is early collaboration on (meta)data standards and interoperability that will ensure the possibility of establishing needed links in the future. As mentioned, common ground may be found through Horizon Europe, EOSC or FAIR. It is through these collaborative processes that standards and methodologies can be adapted and cross-domain synergies elucidated. From the knowledge and experience gained, further decisions can be then be made about the direction and extent, or wisdom, of continued collaboration.

The suggested approaches are not mutually exclusive, and Allmendinger (2015), the EC-RISE author of the policy brief advising the EC Commissioner for Research, Science and Innovation, wisely cautions that there is no empirical evidence for staging or supporting interdisciplinary research or evaluating its added value. Ironically, more interdisciplinarity and organizational experiments are needed to advance it and learn what is needed to nurture and sustain it. Interdisciplinary research requires high investments in time and resources for highly unclear outcomes and may not fit the well-established scientific routines, efficiencies, or standards of research excellence. So for scientists accustomed to the certitudes of empirical evidence, quantified added value, clearly defined outcomes, efficient routines and standards of excellence, interdisciplinary collaborations

[6] In 2016, NHM London piloted a project using a structured and data-driven approach for assessing and working with collections to identify and prioritize investment and effort, monitor the impact of the work, enhance strategic management and contribute to an open, discoverable catalogue of global collections. The methodology was pioneered by the Smithsonian National Museum of Natural History in 2009 (then called *Move the Dots*), adapted by NHM London and re-christened *Join the Dots,* and has been subsequently implemented by MfN Berlin and Naturalis Biodiversity Center. Use cases include prioritizing specimen digitisation activities, planning conservation and collection moves, and informing collection development strategy (Woodburn, 2019).

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may require - contrary to their practiced judgement and comfort zone - a temporary suspension of familiar paradigms.

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Grant Agreement No 777483

Appendix 2. Interviewees

Bianca Crowley	Digital Collections Manager **Biodiversity Heritage Library**
Alba Irollo	Research Coordinator **Europeana**
Maarten Heerlien	Head of Collection Information & Archives **Rijksmuseum**, Amsterdam
Eulàlia Gassó-Miracle	**Cultural Heritage Researcher** Naturalis Biodiversity Center
Andreas Weber	**Assistant Professor, Department of Science, Technology and Policy Studies (History)** University of Twente, NL
Pepijn Kamminga	**Bird and Mammal Collection Manager** Naturalis Biodiversity Center
Karien Lahaise	**Library and Archives Collection Manager** Naturalis Biodiversity Center
Arjen Speksnijder	**Head of Laboratories** Naturalis Biodiversity Center
Wendy van Bohemen	**Loan Officer** Naturalis Biodiversity Center

Funded by the Horizon 2020 Framework of the European Union
H2020-INFRADEV-2016-2017
Grant Agreement No 777483

Appendix 3. RT Attendees and Presentations

Presentation	Presenter
Introduction to DiSSCo	**Dimitris Koureas** DiSSCo Coordinator
Results of humanities researcher surveys	**Tina Loo** ICEDIG T9.4/D9.2 Task Lead
Digital needs of humanities researchers	**Andreas Weber** University of Twente (NL), Assistant Professor Department of Science, Technology and Policy Studies (STePS)
Humanities platforms and research infrastructures	**Jane Smith** Vice-Chair, BHL Members' Council and Head, Library and Archives, Natural History Museum London **Marco de Niet** Chair, Europeana Pro Network Association Management Board, Member Europeana Governing Board, Division manager, Research & Education Services / Deputy Director, Leiden University Libraries **Franco Niccolucci** Project Director, ARIADNEplus, Scientific Coordinator, PIN Vast-lab (IT) **Tatja Scholte** E-RIHS Dutch National Coordinator, Senior Researcher, Dutch Cultural Heritage Agency (Rijksdienst voor het Cultureel Erfgoed, RCE) **Sally Chambers** DARIAH Belgian National Coordinator and Senior Management Team National Coordinators Committee, Digital Humanities Research Coordinator, Ghent University Centre for Digital Humanities

Non-Presenting Attendees:

Ana Casino, **DiSSCo** Deputy Coordinator for Communication and Engagement (CETAF, BE)

Sharif Islam, **DiSSCo** Data Architect

Karsten Gödderz, **ICEDIG** D9.2, CETAF Task Partner

Agnes Wijers, **ICEDIG** D9.2, Picturae Task Partner

Luc Willemse, **Naturalis**, ICEDIG Liaison

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H2020-INFRADEV-2016-2017
Grant Agreement No 777483

Appendix 4. Humanities Researcher Survey Results

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H2020-INFRADEV-2016-2017
Grant Agreement No 777483

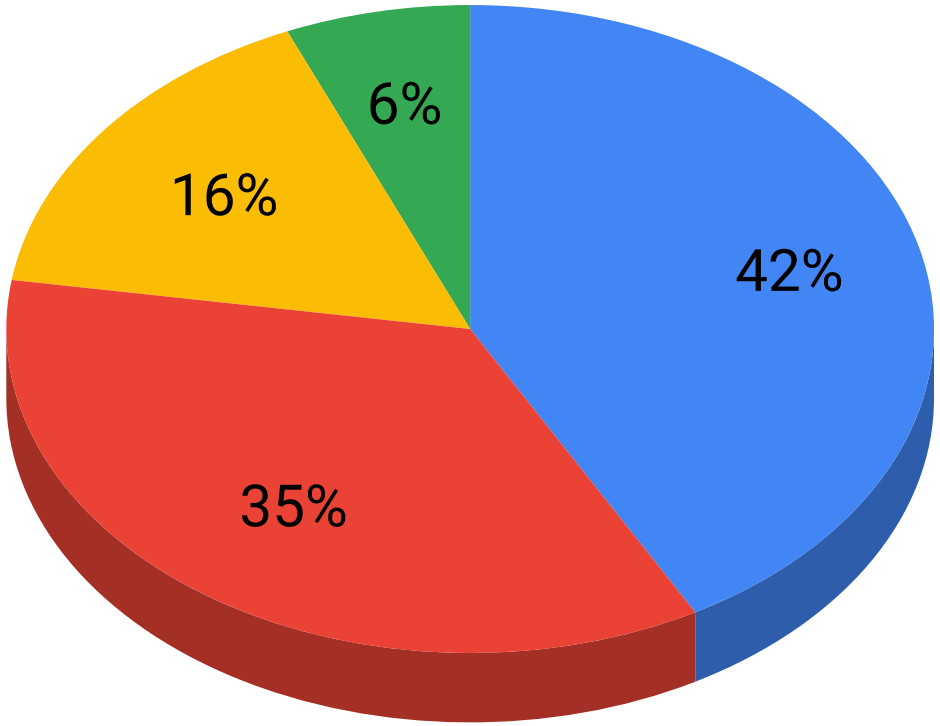
Humanities Researcher Survey

Netherlands	19%
Germany	16%
Austria	13%
Spain	10%
UK	10%
USA	10%
France	6%
Italy	6%
Brazil	3%
Latvia	3%
Poland	3%

31 responses
11 countries

Respondents by Institution

- Universities
- Natural History Museum
- Centers / Institutes
- Botanic Garden



31 responses

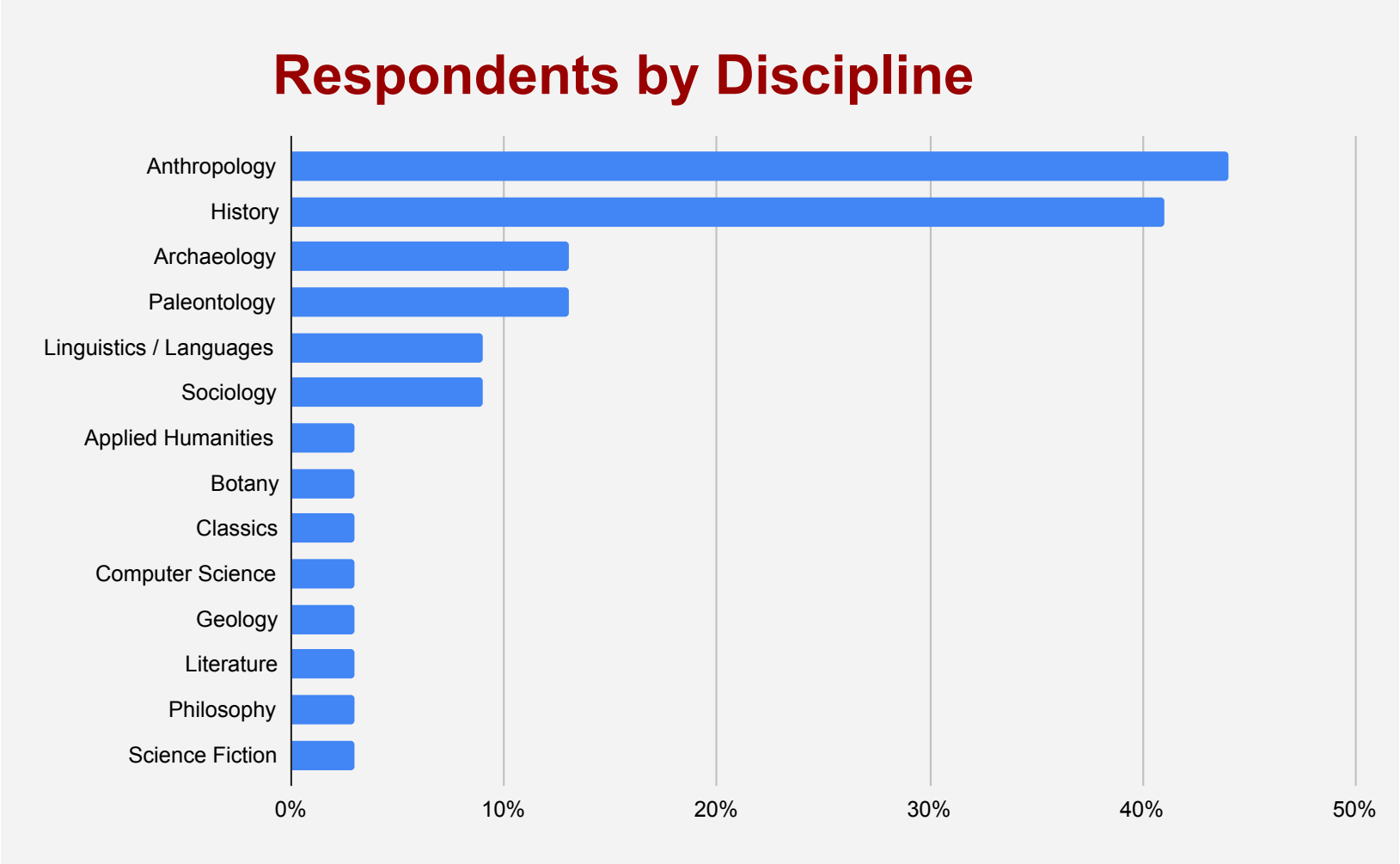
Humanities Researcher Survey

Discipline	Research Interest
Anthropology	Physical anthropology
Anthropology	Ethnoecology, tropical regions; hunter-gatherers; anthropology of food
Anthropology	Ethnoecology
Anthropology, Archaeology	Human Ecology, Human Ecophisiology
Anthropology, Archaeology	Long-term human-environment, especially human-animal interacion, during pre-Columbian and early Historic Era times periods of the circum-Caribbean. I am also actively engaged in the mobilization and digitization of zooarchaeological biological and cultural records as biodiversity specimens in the open access biodiversity network (e.g., GBIF, etc.).
Anthropology, Archaeology, History, Linguistics / Languages	Spatial Humanities, Early Modern, GIS, Corpus Linguistics, AI
Anthropology, Archaeology, Paleontology	Human Evolution, Paleolithique Archaeology, Paleoanthropology, Quaternary Sciences
Anthropology, History	History of Science, Medicine and Empire
Anthropology, History, Philosophy, Sociology, science fiction	Datafication of nature, politics of nature, history of sciences
Anthropology, Sociology	
Anthropology, ethnobotany	Medicinal and ritual plants, transatlantic slavery, historical collections, suriname, west africa
Ethnobotany	Ethnobotany; biocultural heritage
Botany	Cross Cultural Ethnobotany

Humanities Researcher Survey

Discipline	Research Interest
Cultural Heritage	Biology / taxonomy/ 19th century natural history
Applied Humanities	Open innovation in science; applied humanities; knowledge for development; participatory methods; knowledge design; AI; visualization
Classics, Linguistics / Languages, Literature	Digital Philology
Linguistics / Languages	Translation Studies, digital humanities
Computer Science	History of cartography, history of science
History	Provenance research on objects from colonial contexts
History	Various
History	The history of natural history
History	Social and cultural history of botany / natural history
History	History of Entomology
History	History of Sciences, Scientific Illustrations, History of Photography
History	Mediterranean environmental history
Historical ecology, environmental history	Historical ecology, environmental history
History	Geospatial Science, Labour History, Historical demography, Commodity frontiers, Middle Ages, Early Modern
Paleontology	Evolution and systematics of ungulates, biostratigraphy, biogeography, Mio-Plio-Pleistocene, insular ecology and evolution
Paleontology, Earth & Life Sciences	Echinodermata; Phylogeny; Evolution; Systematics; Taxonomy; Nomenclature
Paleontology, Geology	Taphonomy, paleoecology
Sociology	Cultural policy, post-soviet studies, sociology of music, environmental sociology, subcultures

Humanities Researcher Survey

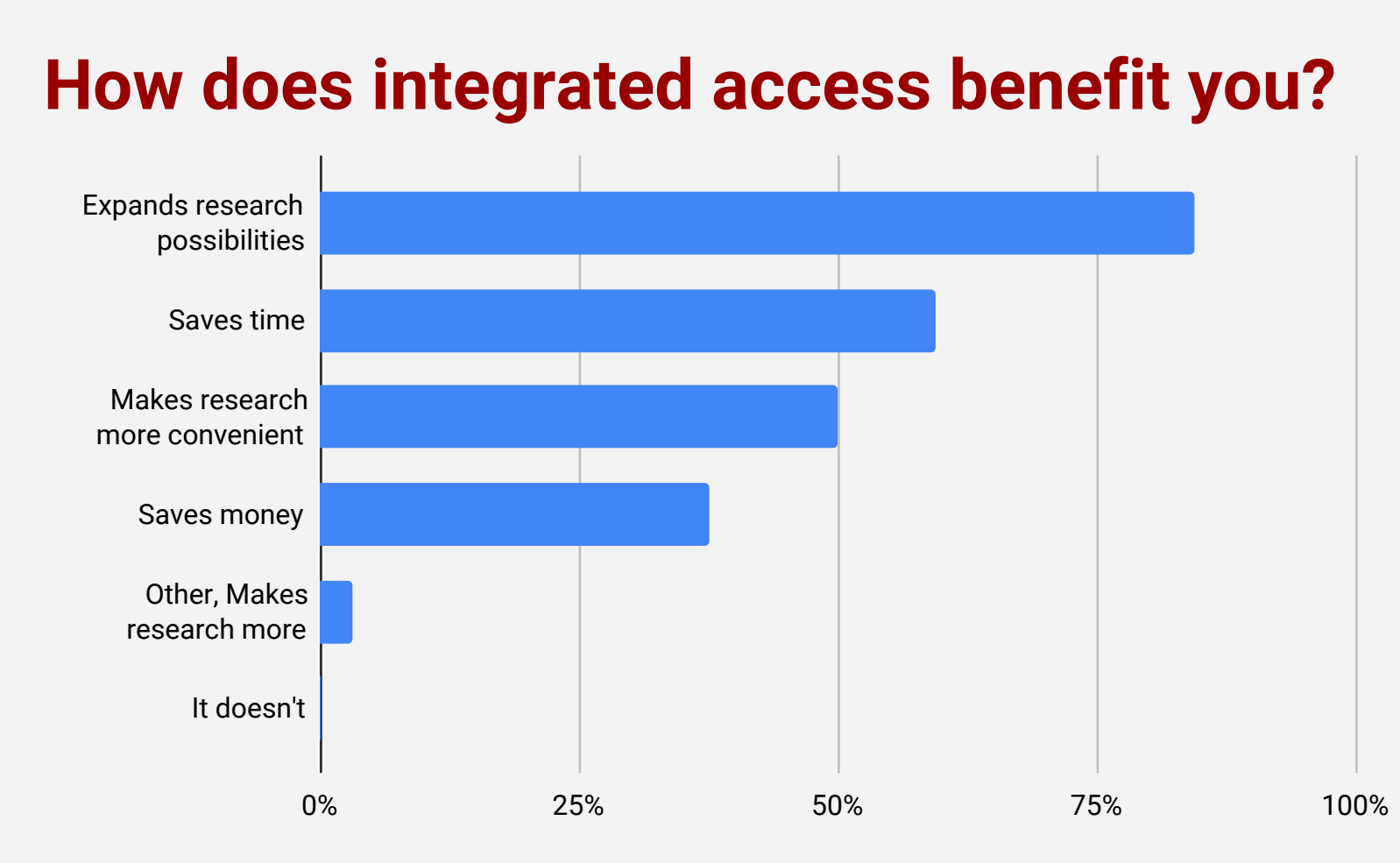


32 responses
14 disciplines

Humanities Researcher Survey

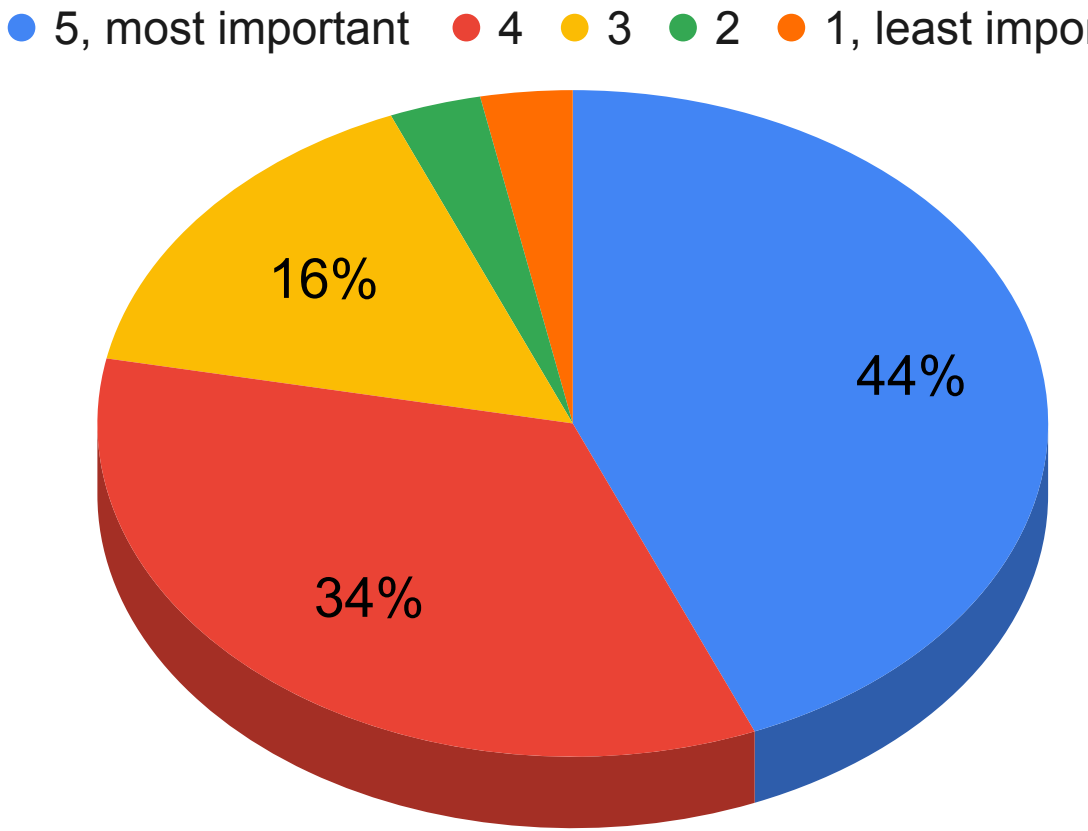
Most Frequently Used RIs

		Percent
BHL		64%
Europeana		32%
GBIF/iDigBio		12%
Home Grown		12%
Ariadne		4%
Other		48%
	Access to physical collections in museums and university laboratories	
	Animalbase	
	Archives (national, regional, academic, etc.), Wikipedia, Delpher	
	Internet Archives; Matricula Online	
	CLARIN	
	Google services (Books, Scholar)	
	Local statistical bureau	
	Open Context	
	Perseus Digital Library, Musisque Deoque, Memorata Poetis	
	ROAD, NQMDB, EVOBREATH, PANTHERIA	
	Scopus	
	Various sources for cartography, scientific instruments	
25	responses	



32 responses
75 answers

How important is integrated access to natural science and archive data?



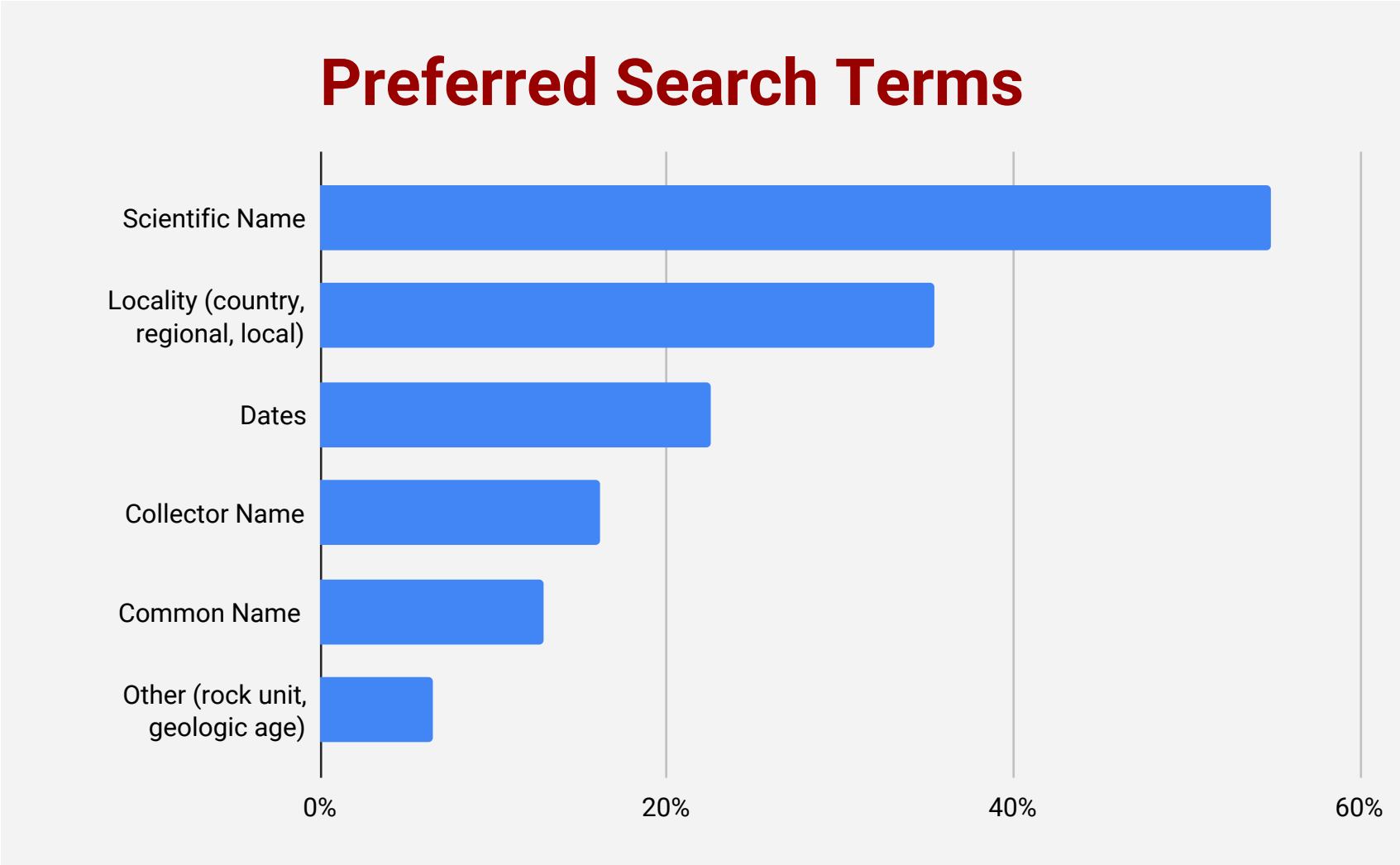
32 responses

Humanities Researcher Survey

Preferred access to natural science collection and archival data

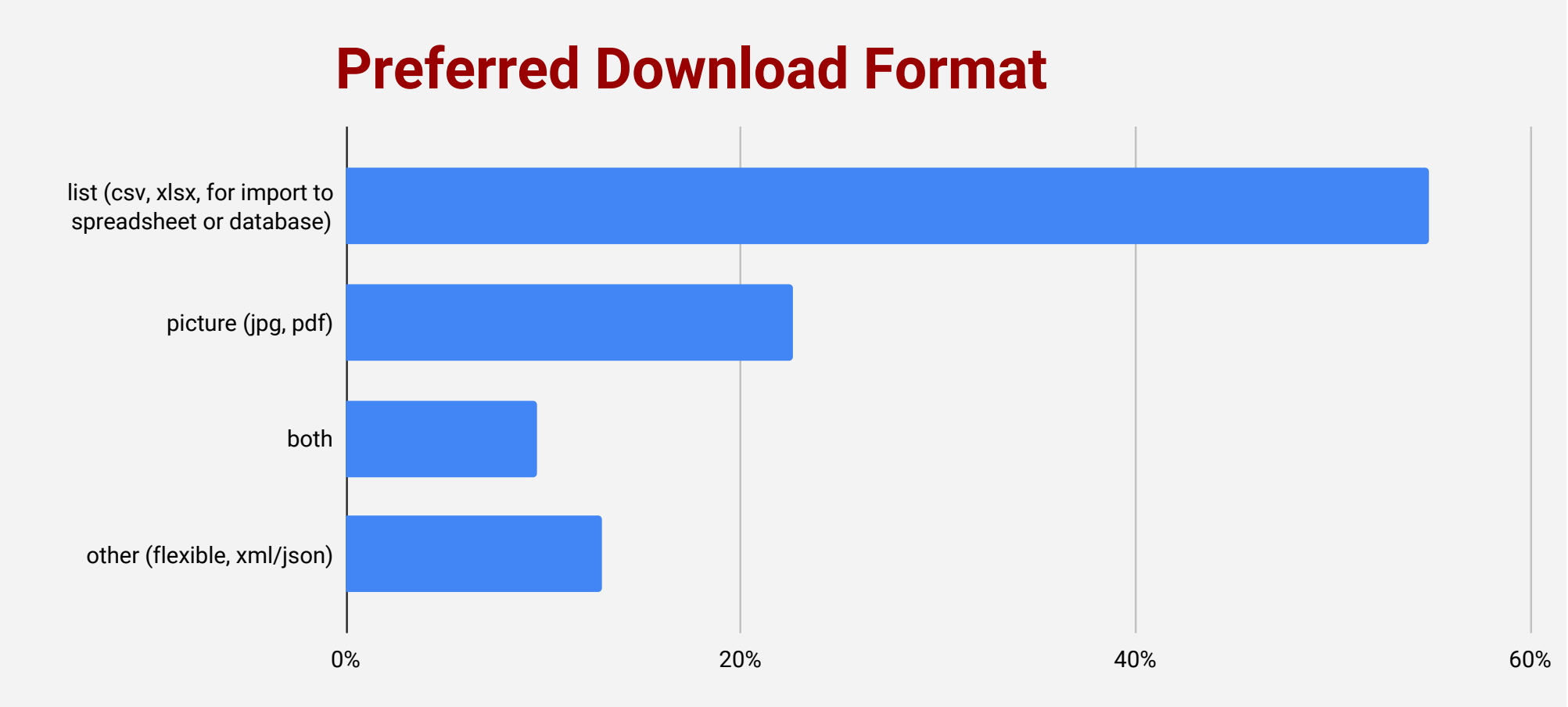
		Percent
Either		44%
Via an online cultural heritage collections resource portal (e.g., BHL, Europeana, Ariadne)		25%
Via a natural science collections data resource portal (e.g., GBIF)		16%
Portal combining both		13%
Physical access		9%
Other		13%
	FAIR data, e.g. Zenodo; project specific/thematic platforms	
	European Open Science Cloud (EOSC)	
	A complete online fossil catalogue	
	Google	
32	responses	

Humanities Researcher Survey



31 responses
46 answers

Humanities Researcher Survey

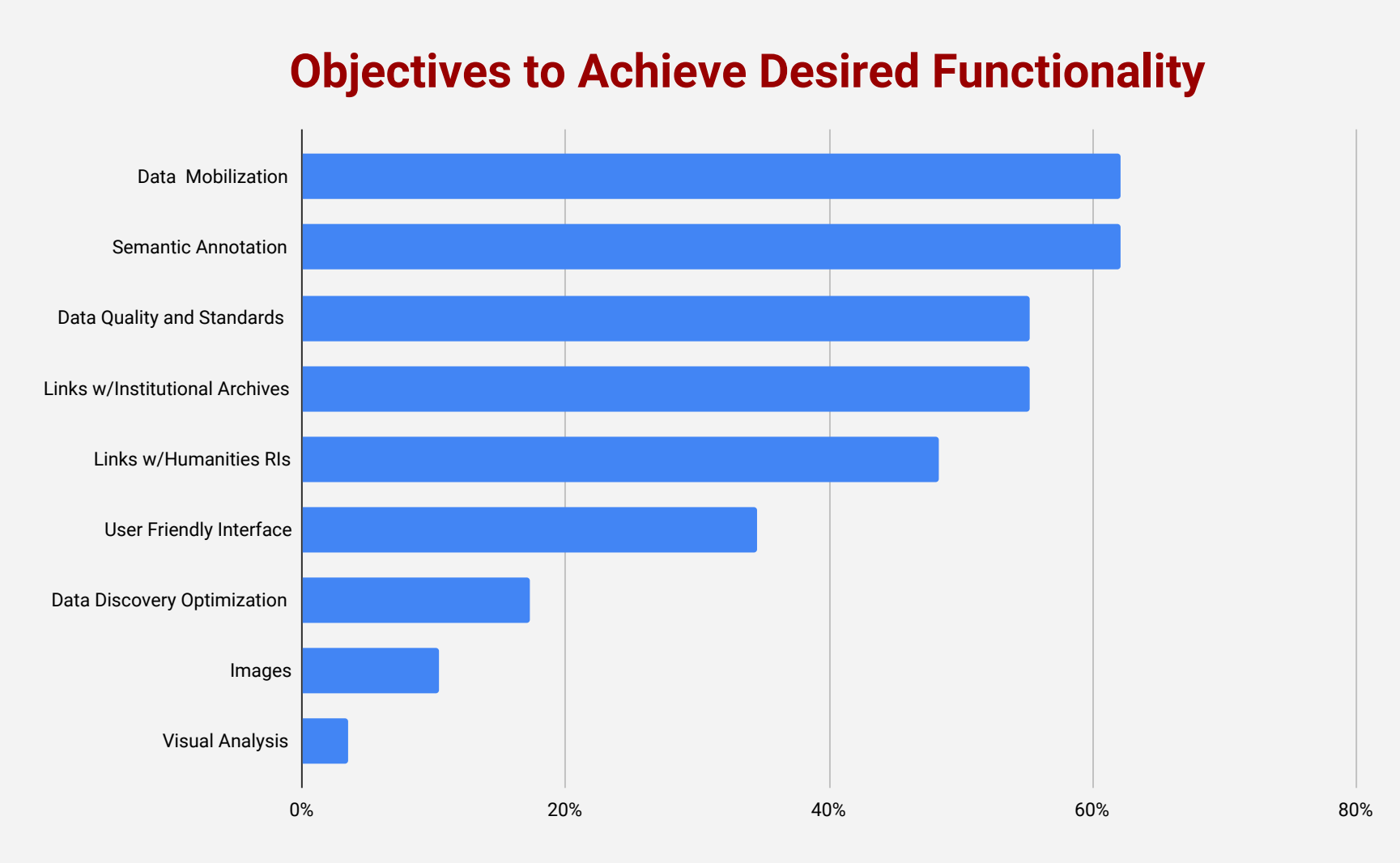


31 responses
31 answers

DESIRED FUNCTIONALITY: FREE TEXT ANSWERS

What functionality would you like to see that would make you more likely to use museum, university, or botanic garden scientific collection objects, data and associated archives, or increase your frequency of use?

see use case and two
connecting more interdisciplinary data on plants and animals in the past
visual analysis; links w/ non natural history knowledge (i work on intersection cultural, linguistic and biodiversity); options and formats to reise e.g. as well 4 arts
linked open data; norm data/authority data
centralised/ aggregator type data base/ repository
easy interfaces to Linked Open Data
Good query functionalities, to combine (fuzzy & augmented) searches for (historical) localities/regions, date, plants, animals, etc.
Better and more complex metadata criteria
linked data across domains/disciplines; be able to browse/see citations of data sorted by discipline; provide critical context for data and collections (context of collection, historical framing, blind spots)
A link between museum objects and their related archives
Datasets that can be easily processed and in machine readable format.
increase the frequency of use
(1) Advanced search facility (e.g. to home in on collector number-lacking in GBIF) (2) High quality standardisation of selected fields (3) free text search across all data (4) complete coverage of collections.
To share informations and learn more!
better search facilities, better download facilities, user-friendly websites
increasing linkages of data
high image quality, resolution
Connection with other databases (cultural, pictures, etc.)
Ability to search easily by date AND place AND name (of collector / specimen) – often I have one or two of those pieces of information but not everything. Ability to do a "fuzzy" search for spelling variants.
More obvious or seamless connection to published work that has also used a particular data set/resource.
Provide as much metadata as you can!
Basic digital data for importing, digital pictures
Catalogues of collections have to be public, complete and up to date. At present, they are mostly of little use.
BHL: There are limitations when downloading or searching the material. You have to go to archive.org for a OCR'd version. You're not able to make your 'own collection' of save your search history. Also would like BHL search results to have links to other platforms
proove availability, find locally published material
Joint portal that allows searches across a wide range of institutions
full text search not only scientific names (e.g. BHL), search across institutions (museums, universities, etc...), visualization of relations/scientific networks across institutions (collectors, Objects etc…)
An ability to link between different open access data and archived record platforms.
Data sharing and export results of my research
integration with other databases, ways to search on collector names



29 responses
87 answers

Section 3 of 4

Use Case #1

The following three questions apply to your first 'use case'.

Please identify the following types of natural science collections data you might use in your research. This data is typically found on the object's label and reflects the collecting event. Check all that apply. (Use Case #1)

- [ ] Scientific Name
- [ ] Sex / Age
- [ ] Part Description
- [ ] Place of Collection or Georeferenced Locality
- [ ] Date of Collection
- [ ] Collector
- [ ] Preparation
- [ ] Object Measurements
- [ ] Photos (scientific)
- [ ] Historic Owners
- [ ] Cause of Death
- [ ] DNA
- [ ] Tissue Sample
- [ ] Other...

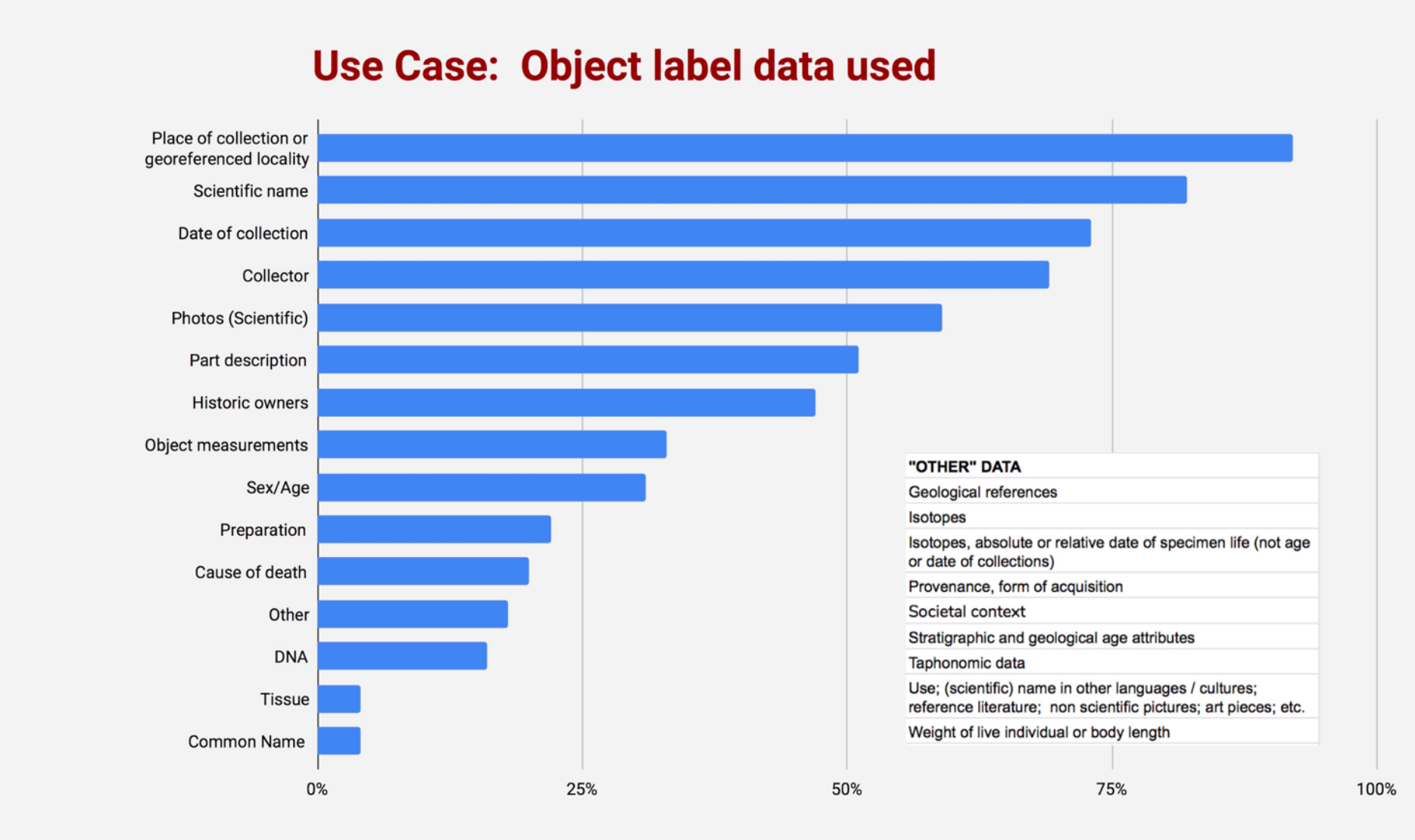
Please identify the following types of natural science archival resources you might use in your research. Check all that apply. (Use Case #1)

- [ ] Accession Books
- [ ] Collection Catalogues
- [ ] Field Notebooks / Diaries
- [ ] Correspondence
- [ ] Raw Data / Notes
- [ ] Biographies
- [ ] (Historic) Maps
- [ ] Drawings
- [ ] Photos
- [ ] Paintings
- [ ] Audio
- [ ] Video
- [ ] Rare Books / Special Collections
- [ ] Other...

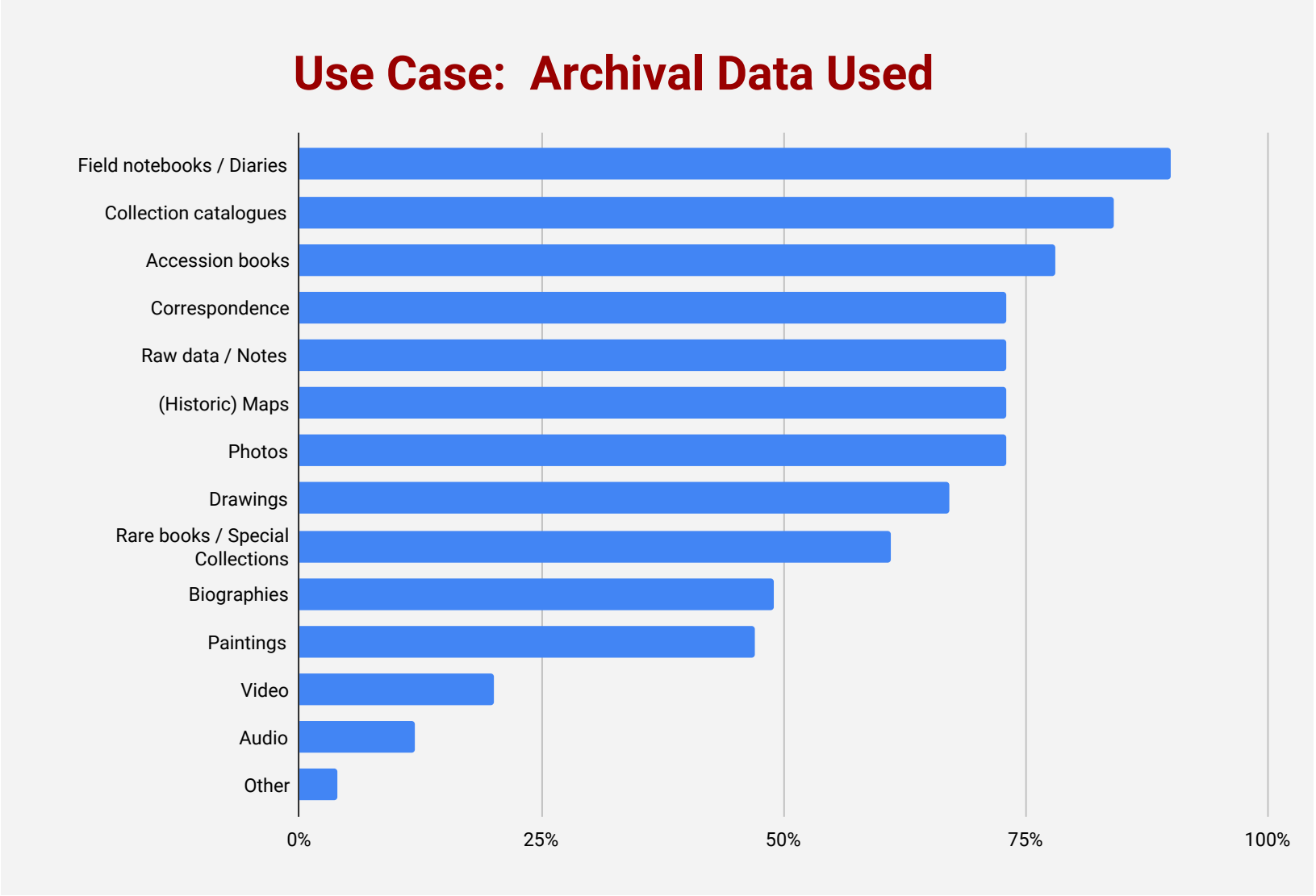
In a few short sentences, please state your research objective for Use Case #1 and briefly describe how the resources check-marked in the two questions above would be used. For example, "IN ORDER TO provide temporal and social context to a painting I NEED TO identify the species of wood of the painting's frame USING the museum's wood reference collection and associated data."

Long-answer text

Humanities Researcher Survey



51 responses
316 answers


Use Case: Archival Data Used
Field notebooks / Diaries
Collection catalogues
Accession books
Correspondence
Raw data / Notes
(Historic) Maps
Photos
Drawings
Rare books / Special Collections
Biographies
Paintings
Video
Audio
Other
0%
25%
50%
75%
100%
51 responses
409 answers

USE CASE
GENERAL CATEGORIZATIONS

- Historic reconstruction of persons, objects, collections, events
- Historic reconstruction to correlate with human influence
- Reference: Identification of species or species comparisons
- Biologic / paleontologic study

USE CASE: Historic reconstruction of persons, objects, collections, events

Discipline / Research Interest	Objective	One Must	Requirement (Inferred)	Data Requirement	Archive Requirement	Survey Number and Use Case Original Text
Historian, History of Sciences, Scientific Illustrations, History of Photography	To fully understand/trace an object or subject's history (how an object came to the institution, provenance, circumstances of collecting event)	Use all available sources of information, images, text (publications, correspondence, notes, etc.) audio, or moving image.	• Integrated humanities and natural science RIs including associated archives. • Semantically linked data	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners Cause of Death Provenance form of acquisition,	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections	**30** UC1: In order to fully understand/trace an objects/subjects history (how an object came to the institution, provenance, circumstances how it was collected) I have to use all available sources be it an image, text (publications, correspondence, notes, etc...), audio or moving image
	To put a collection in socio-historical context	Use all available resources, for example, a specimen's sex, age and date of collection is relevant for identifying a possible bias of the collectors/collection during a certain period of time.		Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections	UC2: In order to put a collection in a socio-historical context I have to use all available sources. For example a specimens sex, age and date of collection is relevant ford identifying a possible bias of the collectors/collection during a certain period in time.

USE CASE: Historic reconstruction to correlate human influence

Discipline / Research Interest	Objective	One Must	Requirement (Inferred)	Data Requirement	Archive Requirement	Survey Number and Use Case Original Text
Anthropologist, Archaeologist Long-term human-environment, especially human-animal interaction, during pre-Columbian and early Historic Era times	To understand the human impact on the spatial, temporal and cultural distribution and use of a species	Quantify the species' presence across sites, create chronological context, and conduct morphological comparisons across individuals	• Integrated humanities and natural science RIs including associated archives. • Semantically linked data	Scientific Name Part Description Place of Collection or Georeferenced Locality Object Measurements DNA isotopes absolute or relative date of specimen life (not age or date of collections)	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps	**31** Long-term human-environment, especially human-animal interacion, during pre-Columbian and early Historic Era times periods of the circum-Caribbean. I am also actively engaged in the mobilization and digitization of zooarchaeological biological and cultural records as biodiversity specimens in the open access biodiversity network (e.g., GBIF, etc.). UC1: In order to understand the human impact on the spatial, temporal, and cultural distribution and use of a species, I need to be able to quantify their presence across sites, create chronological context, and conduct morphological comparisons across individuals.
	To identify patterns of animal management or incipient domestication	• Quantify target taxa across a site(s); • determine age and sex to create mortality and demographic profiles of the taxa, • conduct aDNA to assess impacts of human influence on population genetic diversity, and • use isotopic analysis to assess diet.		Scientific Name Sex / Age DNA isotopes	Field Notebooks / Diaries Raw Data / Notes	UC2: In order to identify patterns of animal management or incipient domestication, I would need to be able to quantify target taxa across a site(s), determine age and sex to create mortality and demographic profiles of the taxa, conduct aDNA to assess impacts of human influence on population genetic diversity, and use isotopic analysis to assess diet.

USE CASE: Reference: Identification of species or species comparisons

Discipline / Research Interest	Objective	One Must	Requirement (Inferred)	Data Requirement	Archive Requirement	Survey Number and Use Case Original Text
Anthropologist, Ethnoecology	To determine the natural species used in the construction of objects	**(I)** Use reference collection objects, online resources and associated archives to identify a species	• Integrated humanities and natural science RIs including associated archives. • Semantically linked data	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Photos	**19** UC1: to determine the natural species used in the construction of objects and to compare objects between our collections and the similar collections in other institutions
	To compare objects between our collections and similar collections in other institutions	**(I)** Have physical or online access to similar collections including data and photos				
	To evaluate changes in the making of objects	Understand object's temporal context		Object Measurements Historic Owners	Accession Books Raw Data / Notes Drawings Paintings	UC2: temporal informations to evaluate the changes in the making of the objects

USE CASE: Biologic / paleontologic study

Discipline / Research Interest	Objective	One Must	Requirement (Inferred)	Data Requirement	Archive Requirement	Survey Number and Use Case Original Text
Anthropologist, Archaeologist, Paleontologist, Human Evolution	To use fossil bones and lithic collections in museum and university collections upon which my research relies	Access their catalogues, digital pictures and drawings (for old collections) as well as any other useful information for my research such as diaries, notes, and letters	• Integrated humanities and natural science RIs including associated archives. • Semantically linked data	Part Description Place of Collection or Georeferenced Locality Date of Collection Object Measurements Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Drawings Photos Rare Books / Special Collections	**24** UC1: In my research I frequently rely on fossil bone and lithic collections stored in museums and university laboratories. To use the collections, it is important to access their catalogues, digital pictures and drawings (for old collections) as well as any other useful information for my research such as diaries, notes, and letters.
	To research fossils and prehistoric stone tools	Compile information such as scientific name, dating, geographic information on the localities where they were found, basic quantitative and qualitative description. Other data needed is field notes, illustration (drawings and photos), and any other useful information about them that was published or unpublished.		Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Object Measurements Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Rare Books / Special Collections	UC2: For my research on fossils and prehistoric stone tools, I would need information such as scientific name, dating, geographic information on the localities where they were found, basic quantitative and qualitative description. Other data needed is field notes, illustration (drawings and photos), and any other useful information about them that was published or unpublished.

Appendix 5. Use Cases - Humanities, Science and Museum

Funded by the Horizon 2020 Framework of the European Union
H2020-INFRADEV-2016-2017
Grant Agreement No 777483

HISTORIC RECONSTRUCTION OF PERSONS, OBJECTS, COLLECTIONS, EVENTS

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist Ethnoecology	To evaluate changes in the making of objects	Understand object's temporal context	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Object Measurements Historic Owners	Accession Books Raw Data / Notes Drawings Paintings
Anthropologist Ethnoecology	To confirm presence and use of plants (date palms for instance)	Check the existence, date of sampling, local names, description of uses, etc. of date palms in collections	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) DNA	Accession Books Collection Catalogues Field Notebooks / Diaries Photos
Anthropologist Physical Anthropology	To study the history of collections	Check the accession books, field notes or diaries, and possibly correspondence and notes	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Collector Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Rare Books / Special Collections
Anthropologist Physical Anthropology	To reconstruct a prehistorical population	Identify the field notes and drawings of the archaeologist	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Drawings Photos
Anthropologist, Historian, Philosopher, Sociologist Science fiction, Datafication of nature	To understand the transforming objectivities [*sic*] of specimen in natural history collections, and trace them across different media and databases		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Photos (scientific) Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections

*Any entries preceded with "(I)" have been inferred, based on evaluation of stated objective, corresponding task, and/or identified use of label data and archive resources.

HISTORIC RECONSTRUCTION OF PERSONS, OBJECTS, COLLECTIONS, EVENTS

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Ethnobotanist Biocultural Heritage	To infer about the history of biodiversity in the area of the Brazilian Amazon.	Use information from historical collections that have information to be integrated.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific)	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Video Rare Books / Special Collections
Historian	To investigate the collection of a particular species of crocodile from an expedition to Borneo around 1840	Locate digitized specimen collection records, associated photos and archives describing the collecting event.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners Other: societal context of object at the time of collection	Accession Books Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Paintings Rare Books / Special Collections
Historian	To investigate the collection of a particular species of crocodile from an expedition to Borneo around 1840	Locate all specimens and objects associated with a particular expedition or exhibition.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of collection or Georeferenced Locality Date of Collection Collector Preparation Photos (scientific) Historic Owners Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographie (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Historian The history of natural history	To write an object biography of an important object from a natural history museum.	Ascertain all relevant historical information.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners	Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Drawings Photos Paintings Rare Books / Special Collections
Historian The history of natural history	To write the biography of a natural historian/collector.	Trace the life and daily practices of the person.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Collector Photos (scientific)	Field Notebooks / Diaries Correspondence Biographies Drawings Photos Paintings

*Any entries preceded with "(I)" have been inferred, based on evaluation of stated objective, corresponding task, and/or identified use of label data and archive resources.

HISTORIC RECONSTRUCTION OF PERSONS, OBJECTS, COLLECTIONS, EVENTS

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Historian Cultural Heritage	To trace the origin, movement and history of collections	Access archives using data on the object label	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Drawings Rare Books / Special Collections
Historian Cultural Heritage	To establish the history of science (taxonomy in the 19th C)	Look up archival resources using data on the object label	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Preparation	Correspondence Biographies Drawings Rare Books / Special Collections
Historian History of Sciences, Scientific Illustrations, History of Photography	To fully understand/trace an object or subject's history (how an object came to the institution, provenance, circumstances of collecting event)	Use all available sources of information, images, text (publications, correspondence, notes, etc.) audio, or moving image.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners Cause of Death Provenance form of acquisition,	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections
Sociologist Cultural policy	Historic reconstruction of something or someone		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Place of Collection or Georeferenced Locality Date of Collection	Field Notebooks / Diaries Raw Data / Notes Biographies (Historic) Maps Photos Audio Video

*Any entries preceded with "(I)" have been inferred, based on evaluation of stated objective, corresponding task, and/or identified use of label data and archive resources.

HISTORIC RECONSTRUCTION AND HUMAN INFLUENCE

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist Ethnoecology	To analyze the evolution of agriculture in an oasis	Check all mentions of plants (with date, attribution) used, collected, traded, etc. in a given area	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos
Anthropologist, Archaeologist Long-term human-environment, especially human-animal interaction, during pre-Columbian and early Historic Era times	To understand the human impact on the spatial, temporal and cultural distribution and use of a species	Quantify the species' presence across sites, create chronological context, and conduct morphological comparisons across individuals	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Object Measurements DNA isotopes absolute or relative date of specimen life (not age or date of collections)	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps
Anthropologist, Archaeologist Long-term human-environment, especially human-animal interaction, during pre-Columbian and early Historic Era times	To identify patterns of animal management or incipient domestication	Quantify target taxa across a site(s), determine age and sex to create mortality and demographic profiles of the taxa, conduct aDNA to assess impacts of human influence on population genetic diversity, and use isotopic analysis to assess diet.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age DNA isotopes	Field Notebooks / Diaries Raw Data / Notes
Anthropologist, Archaeologist, Historian, Linguist / Languages Spatial Humanities	To investigate the historical exploitation of resources	(I) Track the collection, use and dissemination of the resource, and understand its cultural value.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Date of Collection Object Measurements	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections

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HISTORIC RECONSTRUCTION AND HUMAN INFLUENCE

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist, Historian History of Science	To understand how a group of ethnobotanical specimens was collected and what this tells us about (a) the source community and (b) the motivations of the collectors and subsequent institutions.	Know exactly where and when collected, what kind of data (e.g., vernacular names, uses) was collected, and subsequent movements of the specimens including public display in galleries where this occurred.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Anthropologist, Historian, Philosopher, Sociologist Science fiction, Datafication of nature	To follow the epistemic life of an object as it is involved and shapes research practices		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Photos (scientific) DNA Geological references	Accession Books Collection Catalogues Field Notebooks / Diaries Raw Data / Notes Photos scientific publications
Historian History of Sciences, Scientific Illustrations, History of Photography	To put a collection in socio-historical context	Use all available resources, for example, a specimen's sex, age and date of collection is relevant for identifying a possible bias of the collectors/collection during a certain period of time.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners Cause of Death	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections
Historian Geospatial Science	To understand historical disseminations of plants and animals, and long-term human influence on these; as well as how these collections have been constructed in a colonial/imperial/globalization context.		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Part Description Place of Collection or Georeferenced Locality Date of Collection Collector	Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Rare Books / Special Collections

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REFERENCE: SPECIES ID OR COMPARISON

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist Ethnoecology	To determine the natural species used in the construction of objects	(I) Use reference collection objects, online resources and associated archives (photos) to identify a species	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Photos
Anthropologist Ethnoecology	To compare objects between our collections and similar collections in other institutions	(I) Have physical or online access to similar collections including data and photos	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Photos
Anthropologist, Ethnobotanist Medicinal and ritual plants	To compare plant uses	Have access to field notes or accession books as the information is often not written on object labels or not digitized from labels.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners DNA	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Anthropologist, Historian History of Science	To check identification of plant material in an ethnographic object.	Check resources to enable me to determine what was available in the region and what it looks like.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners	Drawings Photos Paintings
Art Historian	To identify species and age of art materials provides temporal, social context	Identify organic materials used in art (wood frames, paints)	Reference collection, expertise, or DNA fingerprint		
Art Historian	To identify plants, animals and landscapes in frescoed rooms of Palazzo Vecchio, Florence, IT to create naturalistic guide of the Palazzo.		(I) Integrated natural science collections data and archive resource. Semantically linked data.		

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REFERENCE: SPECIES ID OR COMPARISON

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Botanist Cross-cultural Ethnobotany	To collect ethnobotanical data and specimen, and be able to compare the data with previous literature.	Have access to a comprehensive stock of online resources	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Preparation Photos (scientific)	Accession Books Collection Catalogues Field Notebooks / Diaries Biographies Drawings Photos Video Rare Books / Special Collections
Botanist Cross-cultural Ethnobotany	To verify and comprehensively compare my data with authentic online easily available resources		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Preparation Photos (scientific)	Accession Books Collection Catalogues Field Notebooks / Diaries Raw Data / Notes Photos Video Rare Books / Special Collections

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NATURAL SCIENCE RESEARCH

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Community Ecologist	Occurrence data with meta-info		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Accession Books Field Notebooks / Diaries Raw Data, Notes
Entomologist	To compare written descriptions to the material I have access to for taxonomic revision	Access original species descriptions and original type material, particularly older taxonomic works	Digitized custom-downloadable taxonomic descriptions *allows faster and easier access to papers I would have otherwise had to wait weeks for and access to many other papers I might not have been able to obtain at all. *allows me to quickly locate original descriptions from early taxonomic authors, particularly in old, rare, or large books		
Geologist	To fill-in data gaps regarding specimens and collections with limited (species name and locality) data.		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data, Notes Biographies Rare Books / Special Collections (Historic) Maps Photos
Paleobiologist	Reassess the taxonomy of fossil mammals from India, the biogeography of South Asian mammals, and paleocommunity change	Identify key specimens for comparison	Digitized catalogues of fossil mammals, reptiles, amphibians and birds for Henry Woodward, the first formal descriptive documents on Falconer's Siwalik fossils including lectotypes.		

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NATURAL SCIENCE RESEARCH

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Paleontologist Evolution and Systematics of Ungulates	To study the evolution of animals in Prehistory	Know the species present in a locality (for zooarchaeological studies), the age of the site, and the environment	(I) Integrated natural science collections data and archive resource. including georeferenced localities and visualization aids (photos, drawings, mapping).	Scientific Name Place of Collection or Georeferenced Locality (I) Weight and Body Length of Live Specimen Most of the information you mention is relevant, but it is sufficient if it is available in a public catalogue. The objects label in the collection, should help idintify the specimen and protect it against being mislaid. Apparently, you are not thinking of a fossil here. This makes a big	Accession Books Collection Catalogues (I) Photos (I) Drawings Notes I might have used many of those, if I had been given easy access to them. I marked what I used. Apart form that, I have my own collection of photographs (>100000) and drawings and notes (about 120 folders or 4.5 m of shelves).
Paleontologist, Earth & Life Scientist Echinodermata	To better understand the evolution of organisms	Access well preserved representative collection specimens to score morphological characters to take samples for genetic and genomic research	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Collector DNA Tissue Sample	Accession Books Collection Catalogues Photos
Paleontologist, Earth & Life Scientist Echinodermata	To link taxon names to clades	Access to type materials	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Collector DNA Tissue Sample	Accession Books Collection Catalogues Photos
Paleontologist, Earth & Life Scientist Echinodermata	To understand what previous researchers meant by a specific taxon name	Access collection catalogues, accession books, literature, or where provenance is unclear, biographic material, field notes, and historical maps	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Biographies (Historic) Maps Rare Books / Special Collections

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NATURAL SCIENCE RESEARCH

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Paleontologist, Geologist Taphonomy	To analyze the impact of climate change on generic diversity, paleocommunities, and substrate affinity	Test whether genera have substrate level preferences that led to a reorganization of the geographic ranges of several common genera, and to determine if high-latitude genera preferentially survived the extinction event. Determine if high-latitude genera preferentially survived the extinction event.	ePANDDA portal facilitates rapid removal of redundant specimens, standardization of taxonomic classification, determination of the ecological characteristics associated with occurrences, and easy plotting of the geographic ranges of brachiopod genera through time. Epandda connects three established, well-supported, and critically important data sources: the Paleobiology Database (PBDB, paleontological,	Scientific Name Place of Collection or Georeferenced Locality Collector Object Measurements Photos (scientific) stratigraphic and geological age attributes	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Photos
Paleontologist, Geologist Taphonomy		live-dead analysis for conservation paleobiology	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Date of Collection Object Measurements taphonomic data	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps
Paleontologist, Geologist Taphonomy	To study how climatic changes drove thermophilous mollusk species migrations during the Pleistocene	Access georeferenced modern and fossil occurrence data for species throughout their geographic distributions in the Atlantic Verify taxonomy of each species occurrence and pair with temperature and salinity measurements. Four separate databases (the Paleobiology Database, the World Registry of Marine Species, Ocean Biogeographic Information System, and the World Ocean Database) had to be searched	Single database interface linking specimens with their literature or metadata. ePANDDA allows a researcher to run a single search, via a single database's interface, view photographs from museum catalogues to verify species identifications, combine fossil and modern datasets, and reconstruct a highly detailed picture of species migrations and responses to climate change.		
Paleontologist, Geologist Taphonomy	To easily discover specimen-related literature and speed data recovery	Now, one must search separately in two or more distinct databases which can be tedious and slow, or rely on institutional memory or long-term collections staff potentially lost to retirement	Single database interface linking specimens with their literature or metadata.		

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SCIENTIFIC INQUIRY

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist, Archaeologist, Paleontologist Human Evolution	To use fossil bones and lithic collections in museum and university collections upon which my research relies	Access their catalogues, digital pictures and drawings (for old collections) as well as any other useful information for my research such as diaries, notes, and letters	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Part Description Place of Collection or Georeferenced Locality Date of Collection Object Measurements Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Drawings Photos Rare Books / Special Collections
Anthropologist, Archaeologist, Paleontologist Human Evolution	To research fossils and prehistoric stone tools	Compile information such as scientific name, dating, geographic information on the localities where they were found, basic quantitative and qualitative description. Other data needed is field notes, illustration (drawings and photos), and any other useful information about them that was published or unpublished.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Object Measurements Photos (scientific)	Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Rare Books / Special Collections
Anthropologist, Archaeologist, Paleontologist	To trace diseases affecting past populations and understand their origin and diffusion through identification of bacterial DNA.	Macroscopic, histologic and radiographic study of lesions on the skeleton.	Osteologic collections as an anthropologic archive.		
Anthropologist, Archaeologist, Paleontologist	To investigate the type of work done and formulate hypotheses about the economy, lifestyle, and division of labor within ancient societies.	Use skeletal lesions to diagnose traumatic episodes, consequences of conflicts between individuals, and ('stress-markers') evidence of repetitively performed movements, posture and mechanical load borne.	Osteologic collections as an anthropologic archive.		
Anthropologist, Archaeologist, Paleontologist	Reconstruct diet of past populations.	Analysis of stable isotopes of carbon and nitrogen on human skeletal remains, allows association of istotopic ratio of these elements with large classes of food.	Osteologic collections as an anthropologic archive.	Isotopes	
Anthropologist, Archaeologist, Paleontologist	Study origin of populations and relations between them.	Study genetically determined characteristics (structure of dental tubercles and non-metric skeletal) to be used as markers of affinity and migration.	Osteologic collections as an anthropologic archive.		

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SCIENTIFIC INQUIRY

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist, Archaeologist, Paleontologist	Attribute an age to finds.	Date bone tissue with radioactive isotopes.	Osteologic collections as an anthropologic archive.	Isotopes	
Anthropologist, Archaeologist, Paleontologist	Determine origin and migration routes of contemporary aboriginal populations.	Ancient DNA analysis to identify genetic characteristics.	Osteologic collections as an anthropologic archive.	aDNA	
Anthropologist, Ethnobotanist Medicinal and ritual plants	To study historic rice specimens	Have access to associated data which are often not mentioned on the labels or digitized from the labels.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners DNA	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Archive Manager	Facilitate volunteer or crowd-sourced object registration and transcription		Digitized accession books, field notebooks, collection catalogues		
Collection Manager	Registration	Have access to primary data sources	(I) Integrated natural science collections data and archive resource. Semantically linked data.		Accession Books Collection Catalogues Field Notebooks Correspondence
Collection Manager	Special requests on specimen's history		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Rare books / special collections
Collection Manager	Identify type specimens	Find original publication	(I) Integrated natural science collections data and archive resource. Semantically linked data.		Original literature
Collection Manager	To ID (exotic) species in the collection	Access unique information such as orginal descriptions, pictures or species drawings	(I) Integrated natural science collections data and archive resource. Semantically linked data.		Accession Books Rare Books / Special Collections Photos
Collection Manager	Make a locality check or search for old and correct names for labeling		(I) Integrated natural science collections data and archive resource. Semantically linked data.		(Historic) Maps

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All Use Cases for a Natural Science Collections Data and Archive Resource BY USE CATEGORY*

SCIENTIFIC INQUIRY

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Curator	Find missing information on specimen labels		Digitized literature		
Curator	Find type specimens in the collection, correctly identify them as types, and then update our records accordingly	Use the taxonomic name finding feature to locate literature on specific species, download relevant documents as PDFs, and link to useful references using page permalinks	Quick access to old references and being able to download them		
Curator	Document curatorial decisions	Attach relevant references to the specimen record	Custom downloadable references		
Georeferencer	To be able to add georeferenced occurrence points to locality data	Refine or verify collecting locality	Digitized accession books, collection catalogues, and field notebooks		Accession Books Collection Catalogues Field Notebooks
Historical Ecologist / Environmental Historian	To reconstruct biodiversity in the past	Obtain occurrence and abundance data in the past	(I) Integrated natural science collections data and archive resource with georeferenced localities and visualization (mapping).	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Object Measurements Cause of Death	Accession Books Field Notebooks / Diaries Raw Data / Notes (Historic) Maps Photos Paintings
Museum Preparator	When restoring historical specimens we need as much information as possible about how they were prepared		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence
Museum Preparator	Reconstruct anatomically correct unique specimens	Have quick reference from workstation, home computer, or phone.	Digitized detailed descriptions and illustrations of specimens		

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EDUCATION / EXHIBITIONS

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Collection Manager	Outreach		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Photos
Head, Educational Development	EDUCATION: We could use this for context rich, digital educational activities. In which we not only focus on biological concepts, but also on the cultural historic aspect of our collection and research. This fits well with our goals to enhance science literacy.		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Field Notebooks / Diaries Correspondence (Historic) Maps Drawings Photos Paintings Audio Video
Manager, Digital Collections and Citizen Science	EXHIBITIONS: Create online and in-house exhibitions focused around expeditions where specimens and cultural objects tell a story of what was collected and what existed along their expedition path, their field notes (from Archives) describe their daily activities in a way which cannot be gleaned through the scientific record of collection and publication and add a humanities angle to the expedition, the literature that arose from specimens found on the expedition can be sourced from the library etc etc. So the stories and the data are there for exploring not just the biodiversity of the time and		Archives		

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All Use Cases for a Natural Science Collections Data and Archive Resource BY USE CATEGORY*

UNIQUE

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Applied Humanities Open innovation in science	To understand the connection of cultural, linguistic and bio-diversity		(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Cause of Death DNA Tissue Sample Other: common name/s; use; (scientific) name in other languages / cultures; reference literature; non scientifc pictures; art pieces; etc.	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections
Classicist, Linguist / Languages Literature, Digital Philology	To connect realia to encyclopedic information for historical documents (e.g. WWI & WWII documents or ancient Greek documents	(I) make augmented text searches; establish georeferenced localities	(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings Audio Video Rare Books / Special Collections
Forensic Facial Reconstructionist Facial 3D Modeling	Bring a face from the past alive (famous historical figures, archaeological dig). Determine if two skulls from same family or population.		(I) Osteologic collections as an anthropologic archive	(I) DNA	Photos
Organologist (Musical Instrumentation)	Investigating fault lines between biological sciences and organology. Organologists use biological sciences as examples for their taxonomies, classification systems, paradigms, etc. - from the 19thC onwards and even today. Options discussed in these sciences are still relevant to organology. Even the 'evolutionary theory' of musical instruments has much to learn from cladistics.		(I) Access to taxonomic backbone via integrated natural science collections data and archive resource.		

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All Use Cases for a Natural Science Collections Data and Archive Resource BY USE CATEGORY*

UNIQUE

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Philosopher History of Philosophy, History of Science	To develop an exhibition on Poetic Botany (an 18thC movement championed by Charles Darwin's grandfather in which botany became the subject of poetry, i.e., scientific botanic characteristics of a plant are expressed in poetry).	To search by species for 18th C texts	(I) Integrated natural science collections data and archive resource. Semantically linked data.		
Saxophonist, Composer, Producer, Educator	To correlate changes into repetitive DNA elements in genes to orchid floral shapes		(I) Integrated natural science collections data and archive resource. Semantically linked data.		Photos
Saxophonist, Composer, Producer, Educator	To compose an étude (Orchidées) on the evolution of the genus Orchidaceae.	Map the nucleobase and amino acid sequences that comprise the orchid's DNA codes to form individual movements for each of the five evolutionary families of the genus.	(I) Integrated natural science collections data and archive resource. Semantically linked data.	DNA sequences	

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MUSEUM LABORATORIES

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Archaeologist	To determine population migration and trading routes	Determine species of ivory tusk (African or Asian)	DNA Fingerprint / barcoding		
Art Historian, Chemist, Conservator	To determine the likely attribution of a painting.	Use MA-XRF to analyze 'under' painting in an overpainted canvas to gain a clearer picture of brushstrokes, outlining techniques, cracks in overpainting and signature.	By using MA-XRF, a multidisciplinary team of chemists, conservators and art-historians, other works of vanGogh and his correspondence, strong arguments for the authorship of van Gogh were established. Gaining insights into an artwork's condition affects our understanding and interpretation of that object.		

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USE CASE UNANSWERED BUT IDENTIFIED LABEL AND ARCHIVE DATA INDICATE NEED

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Anthropologist, Archaeologist, Human Ecology			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Object Measurements Photos (scientific) Cause of Death	Collection Catalogues Field Notebooks / Diaries Raw Data / Notes (Historic) Maps Drawings Photos
Anthropologist, Sociologist			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Part Description Place of Collection or Georeferenced Locality Date of Collection Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Computer Scientist History of Cartography, History of Science			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Object Measurements Photos (scientific) Historic Owners	Accession Books Collection Catalogues Raw Data / Notes (Historic) Maps Drawings Photos Paintings Rare Books / Special Collections
Ethnobotanist Biocultural Heritage			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific) Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Video Rare Books / Special Collections

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USE CASE UNANSWERED BUT IDENTIFIED LABEL AND ARCHIVE DATA INDICATE NEED

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Historian Social and cultural history of botany / natural history			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners vernacular name	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Paintings Rare Books / Special Collections
Historian Mediterranean Environmental History			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Collector Photos (scientific) Historic Owners	Collection Catalogues Field Notebooks / Diaries Correspondence (Historic) Maps Drawings Paintings Rare Books / Special Collections
Historian History of Entomology			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Paintings Rare Books / Special Collections
Historian Provenance research on objects from colonial contexts			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Place of Collection or Georeferenced Locality Date of Collection Collector Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Photos Rare Books / Special Collections
Historian Provenance research on objects from colonial contexts			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Place of Collection or Georeferenced Locality Date of Collection Collector Photos (scientific) Historic Owners	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Biographies (Historic) Maps Photos

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USE CASE UNANSWERED BUT IDENTIFIED LABEL AND ARCHIVE DATA INDICATE NEED

Discipline/Research Interest	Use Objective	One Must	Requirement	Label Data	Archive Resources
Historian			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name Sex / Age Part Description Place of Collection or Georeferenced Locality Date of Collection Collector Preparation Object Measurements Photos (scientific)	Accession Books Collection Catalogues Field Notebooks / Diaries Correspondence Raw Data / Notes Biographies (Historic) Maps Drawings Photos Paintings
Linguist, Translation Studies			(I) Integrated natural science collections data and archive resource. Semantically linked data.	Scientific Name	Accession Books Collection Catalogues Raw Data / Notes

*Any entries preceded with "(I)" have been inferred, based on evaluation of stated objective, corresponding task, and/or identified use of label data and archive resources.