

Common Names: Cooperative Access to Databased Natural History Information

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Abstract

The design and use of electronic information systems to provide cooperative access to natural history museum collections is influenced by existing traditions of organization of and access to paper-based information about those collections. These information systems lack standardized choices for identifying characteristics and the descriptive terms to specify those characteristics. Initially supplied specimen information is often incomplete and inaccurate, as collections are seldom thoroughly described at the time of discovery, and inconsistent, as taxonomic systems change over time. Accession records vary in levels of detail and are frequently supplemented and validated by information scattered through such archival records as field notes, correspondence, photographs, and other visual records. Although these inconsistencies in an individual museum's records could be accommodated by its own staff and the outside users they directly assist, such information systems may not serve the needs of a more diverse group of users, including public and academic users from other disciplines. While the rhetoric of network culture may imply that the technology that enables cooperation will ensure that cooperation, it is not easily achieved, even when endorsed by professional associations and granting agencies. Examples are drawn from the library community to illustrate solutions to this problem of providing electronic access to records of dissimilar form, content, and descriptive vocabularies.

Specific Needs of Museum Information Systems

Museums can be defined as collections of objects assembled and maintained within a specific intellectual environment. In order to maintain that environment, information about the objects in the museum's collections must be available for use by all the audiences served, including museum staff, administrators, regulatory agencies, subject specialists, and the general public. The apparent desirability of electronic access to collection information is changing the focus of public exhibitions and scientific research. Lynch (1998) noted that while curated exhibitions have been the primary means

of public access to museum collections, with increased electronic access museums will become more like libraries, where users can impose their own order on the collections. Some mechanism must be in place to capture, maintain, and selectively deliver that information, depending on a user's relative need to know. Sensitive information will need to be masked from certain users but made available to others. This sensitive data includes location of such economically exploitable objects as rare minerals, plants with potentially medicinal value, and rarely found and therefore collectible insects and animals. The information system must accommodate the fact that taxonomic systems used to identify individual specimens are cumulative. Modern nomenclature is based on taxonomic decisions published in the past, sometimes as long ago as the eighteenth century. The scientific name initially assigned to a given specimen may change either because of incomplete or incorrect initial identification or subsequent changes in the nomenclatural hierarchy of the organism.

The accession record, the basic element of a museum's traditional record-keeping system, records the transaction by which the object was acquired and describes the object so that it can be identified throughout its life cycle. During their life-cycle stages, as distinguished by Bearman (1987), museum objects are considered, acquired, accessioned, managed, conserved, documented, studied, interpreted, and deaccessioned or destroyed. The information system must maintain the relationship of the object with information concerning the circumstances of the object's discovery and acquisition and the provenance of past ownership, and allow the accumulation of information about the object—even

when it is conflicting—over its lifetime. As nomenclatural information in natural history is notoriously unstable over time, information systems must maintain connections among the original published name of an organism, its currently accepted name, and the historic variants used along the way in taxonomic and bibliographic references. Different levels of specificity, particularly in geographic location information, must also be accommodated by the system, as levels of detail supplied have varied over time and local museum practice.

In paper-based information systems various types of information about the acquisition and identification of a particular specimen were often maintained in multiple files, with long-time museum staff needed to piece together extant records and unwritten museum lore in order to verify questions of circumstances of acquisition or other collection details. As noted in Sarasan's frequently quoted article "Why Museum Computer Projects Fail" (Sarasan, 1981), the inability to incorporate this invisible contextual information into the electronic specimen record was the major cause of failure in early projects to computerize access to specimen information. Acknowledging the need to capture this network of curatorial lore and familiarity with past museum personalities and practices, Sarasan notes that "without oral tradition, many collection information systems would have failed even to fulfill the two basic functions of museum documentation—to lead the user to the specimen in a reasonable period of time, and to interrelate all the information sources so that a user might easily find all the information recorded about a particular object." The institution-specific nature of this information network may argue against cooperative descriptive systems on which the efficiency of shared-access systems is based.

Unlike art objects, which may be cherished for their cultural values, as emblems of power, or even for the raw market value of their materials, natural history museum specimens have neither meaning nor value outside their context of what, where, and when. Physical arrangement of natural history collections carries meaning, as it provides a visual index to the taxonomic context. One proof of the widespread acceptance of this assumption was the simple statement in a popular introductory text to botanical taxonomy that "plants are arranged in the herbarium according to a selected classification" (Lawrence, 1951). This statement introduced the few paragraphs on the relative merits of classification schemes for particular types of herbaria collections and was in marked contrast to the many pages of de-

tailed recommendations for the actual practice of collecting and specimen preparation in the field and in the herbarium.

With the rise of such popular information technologies as the World Wide Web, the public's expectation is increasing that museums will make information on their specimen collections available electronically to a wider range of users than was ever considered possible in the past. Speculating on the role of museums in the electronic age, Sullivan (1998) says that a museum's "walls have become electronically permeable and access to collections in the twenty-first century may become as important as possession of collections was in the twentieth century." To accomplish this in an efficient and timely fashion, museums have been exploring various strategies for providing cooperative access to this electronic information. In the past twenty-five years libraries have benefited from cooperative cataloging initiatives to build their online catalogs, most notably those services provided by OCLC (Online Computer Library Center) and the Research Libraries Group. The museum community, however, has not adopted a similar scheme on the grounds that individual specimens are unique and cannot be managed as uniformly as individual copies of a published book. Lack of a controlled vocabulary, including standardized descriptive terms, limits the effectiveness of searching across collections divided by discipline and institution. Such proponents as Rosenberg (1997) recognize the value of taxonomic databases as guides to both the hierarchical taxonomic structure and standard thesauri (lists of equivalent terms intended to guide the user to the specific vocabulary in a particular information system). He notes that "given the magnitude of the task of capturing data and the paucity of resources for taxonomic pursuits, efficiency in compiling collection databases is critical. Taxonomic databases that document the nomenclature, synonymy, and classification of species and higher taxa can provide greater efficiency and accuracy in computerizing the raw data of collections." But the creation of such cooperative databases has been largely limited to lists of accepted valid names, many of which are available electronically.

Record-Keeping Traditions

The design and use of electronic information systems to provide access to natural history museum collections is influenced by existing traditions of organizing paper-based information about those collections. Record-keeping systems in natural history museums document the work of the institution, which is to collect, to identify, to

preserve, and to provide access to the objects in its collection. In these museums the evidential value of the object itself is supplemented, not supplanted, by the documentary evidence of field notes, photographic and other visual records, formal accession information, and published works referring to that specific object. The disciplines of taxonomy and systematics are used to name and relate objects in a museum's collection. They are what distinguishes the modern natural history museum from the Renaissance's cabinet of curiosities.

Museums are part of a long tradition of data recording, analysis, and dissemination. Researchers have recorded data out of sheer curiosity, out of a desire to pass information on to succeeding generations, for self-aggrandizement, and as a show of power. The creation and maintenance of catalogs of collections removes ambiguity. Westbrook (1992) notes that in 150 B.C. Hipparchus of Rhodes created his star catalog, which listed the location and brightness of over a thousand stars, as he was unable to decide whether a given star was really new to science or had simply been inadequately described in the past. Much of the rationale for the record-keeping systems of the *Kunstkammern*, or cabinets of curiosities, which were accumulated from the mid-sixteenth century through the mid-eighteenth century, is based on much earlier works, including Pliny's *Historia naturalis*, in which the natural curiosities were separated from the man-made ones. Published catalogs of private collections, such as the 1599 *Historia naturale*, which recorded the collection of Ferrante Imperato, or the better-known *Museum Wormianum seu historia rerum rariorum* by Ole Worm, published in Amsterdam in 1655, itemize the holdings of these collections, without much information on the circumstances of collection or records of provenance. Establishing the relationship of one object to another has been the basis of systematics in natural history since the sixteenth-century Moderns declared their superiority over the Greek and Roman Ancients, believing that there was more to nature than there was in Aristotle. Variability in the names of plants and animals, particularly those from exotic locales, was recognized even in fifteenth- and sixteenth-century printed books of flora and fauna. The recording of languages and culture-specific variants of names was an important feature of those publications. One example of the continuing value of this nomenclatural diversity was the inclusion, by reference, of the extensive synonymy of Caspar Bauhin's 1623 *Pinax theatri botanici*, in the major works of the great eighteenth-century systematizer, Carl Linnaeus, including his landmark *Spe-*

cies plantarum, which is the touchstone for modern botanical nomenclature.

Public Access to Museums

Private museums assumed that the personal attention of the museum's owner would serve as curator and interpret the objects for the individual visitor. As these private collections were institutionalized and made available to the public throughout the nineteenth century, curators attempted to serve as personal guides for the public. These attempts met with limited success, often because of the lack of a background common to both visitor and guide or sheer ineptitude on the part of the guides. Early public museums were criticized for their lack of apparent organization of collections in the public exhibition galleries. A visitor to the British Museum in 1786 noted that except for "some fishes in a small apartment which are begun to be classed, nothing is in order, everything is out of place, and this assemblage appears rather an immense magazine, in which things have been thrown at random, than a scientific collection, destined to instruct and honour a great nation" (Ripley, 1969). The modern separation of specimen collections organized for scientific use from objects selected for public display dates to the mid-1860s when these distinctions were debated by John Edward Gray and Richard Owen of the Natural History Departments in the British Museum and applied by William Flower at the Hunterian Museum (Stearn, 1981). Twentieth-century natural history museums are the product of years of refinement of the concept of the "index museum," where selected typical specimens summarize the whole in a relatively small space. It was felt that collections organized of unique, but related specimens, would bewilder and tire the public.

George Browne Goode, assistant secretary of the Smithsonian Institution in the late 1800s, accepted his museum's place in the public tradition of arrangement and description. He wrote in 1895 that a museum should be "much more than a house full of specimens in glass cases. It should be a house full of ideas, arranged with the strictest attention to system." He then continues wryly that "an efficient educational museum may be described as a collection of instructive labels, each illustrated by a well-selected specimen" (Goode, 1895). The arrangement of the collections from the U.S. Exploring Expedition of 1838–42, or U.S. Ex. Ex. as it was referred to, from the name of the expedition as it appeared on the specimen labels, was one of his responsibilities. The collections amassed during the expedition became

the core of the Smithsonian's collections, although there were considerable losses from improper preservation and documentation techniques. When the expedition returned in 1842, no museum was equipped to receive or systematically maintain the artifacts that had been collected. The deposition of the collections in the Smithsonian Institution in 1858, after much discussion and resistance, was one of the major accomplishments of the expedition.

During the third quarter of the nineteenth century in the United States the identification of specimens received from such government-sponsored explorations as the U.S. Ex. Ex. was a major stimulus to the study of natural science. Goode believed that understanding historical processes was essential to describing the present state of scientific knowledge. This approach was consistent with the overall activity in acquiring and organizing documentary evidence, which coincided with the contemporary movement in historical studies led by Herbert Baxter Adams. Concurrent with the movement to collect artifacts of the past was the publication of metaphoric "cabinets," including serial publications that reproduced literary or art works of the past, forming a museum in print. In a more abstract sense specimen collections served as further evidence of the upward spiral of progress and improvement. The cultural historian Henry Shapiro (1985) sees the principal significance of these specimen collections as reminders of "the pastness of the past and as artifacts, of the development of evolutionary sequence that was history . . . and it was as a monument to the distance between past and present, hence proof of the reality of progress and evidence of the character of progress that they were preserved." Throughout the twentieth century, collections continued to grow, as did the costs of housing, preservation, and access. The cost and intellectual burden of rapidly enlarging collections is based on the Darwinian approach that extensive collections are required to elucidate the evolutionary process (McAlpine, 1986). The need for continued growth of specimen collections through additions of "multiple copies" of individual species has been disputed, but generally successfully countered with the argument that a single specimen might be anomalous (Bryant, 1983).

The Rise of Automated Museum Record-Keeping Systems

Sarasan and Neuner's 1983 survey of the computerization of museum collections discusses the collection in-

formation crisis of the 1970s. There was an increasing sense of the public accountability to maintain and provide access to objects maintained by museums as a public trust, combined with an increasing acknowledgment of the difficulty of locating specimens and maintaining access to the information associated with them. Responding to this demand for public accountability, the Commission on Museums for a New Century reviewed existing museum practice and in 1984 proposed a number of objectives with corresponding recommendations for achieving those goals. One goal was the use of information management technology as a means of capturing and preserving specimen or item-level collection data. The commission's report defined the ethical and legal obligations of museums "to maintain and manage the objects entrusted to them and that involves all the activities necessary to preserve objects in perpetuity, to gain intellectual control over them (by acquiring and recording information about them) and to make them accessible to scholars" (Commission on Museums for a New Century, 1984).

The development of automated collections management systems was heralded as the solution to internal and external demands for access. Several museum-developed software packages had appeared in the 1960s, including the Smithsonian's Self-Generating Master (SELGEM), succeeded by the Collection Information System (CIS), an integrated collections management system that combined ongoing specimen documentation of an object's movement through the phases of exhibition, conservation, and loan in a single system. In her survey of North American collection management systems, Sledge (1988) believed that the rush to develop and install such systems was driven by the expectation that automated audit control of collections could be performed if a collection inventory existed. What resulted was a separation of curatorial staff from system developers, even though some curators expanded their traditional responsibilities to include the ability to specify and design an information system. Collection administrators, however, are ambivalent about the merits of this change in curatorial responsibilities, as noted in a recent Association of Systematics Collection (ASC) publication (Zorich & Hoagland, 1995) in which curators are warned against "losing" staff to database management. Sledge's comments that the major effect of the incorporation of computers in a record-keeping system was to highlight the inconsistencies of the existing manual systems were repeated throughout the museum documentation literature.

The British Museum Documentation Association (MDA) was established in 1977 to “assist museums with documentation procedures.” The MDA published *Practical Museum Documentation* in 1980, with a revised edition in 1981. This work was intended as a guide to techniques for documenting a museum collection. At the time of publication the editors were unaware of any similar publication, although they did note several recent books on museum registration techniques, including Orna and Pettit’s 1980 *Information Handling in Museums* and Dudley and Wilkinson’s 1970 *Museum Registration Methods*. Features of an effective museum documentation system, capable of satisfying the “demands of a user, whether a curator, researcher or member of the public,” were described in the 1981 edition of *Practical Museum Documentation*. In addition to being able to handle any number of records of varying length, the ideal museum documentation system should be easy to use and provide quick access to information but have the ability to block general access to whatever types of information are considered confidential.

In the late 1980s the number of publications dealing with collections management systems for museums increased. Collections management had become the fashionable phrase in the 1980s as museums refined their functions and focused more on the need for effective care of their collections than on acquisition. Collections management was the theme of the MDA’s first annual conference in 1987, and its collected papers were prefaced with the statement that museums were working to “control collections and demonstrate accountability, . . . as new computer systems became available for local adoption” (Roberts, 1988). Collections managers were becoming aware of the opportunities for intellectual access as an outgrowth of inventory control and were beginning to see the new information technologies as a way to provide information for research and management at a number of different levels, without multiplying the actual number of records associated with an individual object. The museum accession record was being transformed into the integrated specimen data record. Spiess (1988), whose paper in that collection addressed the policies and procedures of the Smithsonian Institution, stated the need to provide museum-wide access to collections and their associated data in order to support both public education and research and provide an efficient tool for collection management.

The struggle for standards is most evident in the literature dealing with the transition from a manual to an automated record-keeping system. In the introduc-

tion to the 1988 edition of Chenhall and Vance’s *Museum Collections and Computers* the authors compare this work to their 1975 *Museum Cataloging in the Computer Age*, noting that while the basic principles of museum cataloging had not changed, the power of the indexing and access tools available to individuals had. The similarity between museum accession records and library catalog records is stressed, perhaps hoping to console the museum administrators, who formed part of the stated audience of the book. Since libraries had clearly solved the problem of automated collection management, it was assumed that some of their experiences might benefit the museum community. But the contrasts were found to be too great, and the authors recommend the development of separate information systems unique to each museum so that the special needs and requirements of the individual scientific disciplines and the museum administrations themselves might be best accommodated. Chenhall and Vance (1988) believed that it was “not feasible to develop one ‘ideal’ cataloging system that will adequately serve a large number of museums, and in the process, allow the free and easy electronic interchange of all data about all objects in all the museums. The Canadian Heritage Information Network has demonstrated that a single system can serve an entire country, but even with this system it is still necessary for each institution to determine the information that it needs or wants to put into the system.” This work also provides a substantial body of information on what the authors acknowledge as a “rather esoteric field of specialization” dealing with the standardization of interpreted erratic manual practices of the museum accession file, particularly when multiple data files are linked to an acquisition record. While this work was meant as an introduction to the capabilities of databases and the jargon of networking, its bibliography serves as an overview of the museum computer resources and organizations as well as the literature available at the time.

Response from the Professional Organizations

The ASC, founded in 1973, included a Council on Standards for Systematics Collections, which, in addition to developing standards for specimen and data acquisition and documentation, also recognized the importance of electronic data processing for recording and retrieving specimen information. Much of the current work being done in the systematics community is supported by the ASC and deals with the construction of data models and controlled vocabulary in the area of locality data, especially in stabilizing variant forms of place names. As

Bearman (1989) wrote, “terminology standards are the finest sieves in the hierarchy of information standards.” The ASC has issued position papers recommending policies for sharing and use of electronic specimen data (Hathway & Hoagland, 1993; Hoagland, 1994). These guidelines for institutional policies and planning emphasize the significance of accession information as the primary record of accountability. “Accessions result in tangible assets that are held in public trust. Accession policies establish the legal and ethical basis for acquisition and ownership of collections. They are the basis for establishing institutional control over specimens” (Hoagland, 1994).

The British MDA was involved in the development of a standardized system of recording for museums known as the Museum Documentation System, which was adopted throughout the United Kingdom. The MDA proposed several Database Management Systems (DBMS) oriented for specific functions of museums (Thompson, 1992). During this early database period the core set of required fields was hotly debated, with the upshot being that no two museums, even within the same discipline, could wholly agree.

An examination of the professional literature dealing with the documentation of natural history collections—particularly as museums prepare to automate these systems as a means to providing electronic access—shows a struggle toward the adoption of data standards, both in the types of information collected as well as the terms used to describe that information (Moritz, 1989). Members of the individual scientific disciplines have taken responsibility for the definition of the actual fields of data to be collected, producing thesauri and authority files of valid genus and species names, and a wide range of other documentation standards. Effective thesauri depend on authority files, that is, lists of accepted terms for the names of organisms, subject terms, or other descriptors. Use of terms other than those in the authority files, particularly for indexing purposes, results in scattering of references and loss of potentially relevant references to the user.

While the Getty Art History Information Program (AHIP), now the Getty Information Institute, has taken the lead in developing standards for the electronic interchange of images and textual data related to collections held by art and cultural heritage museums, there is no similar widely acknowledged leadership in the development of standards for descriptions of natural history collections. One hypothesis for this delay is that museum curators consider each item in the collection unique, so

that attempts at cooperative cataloging have little value for the individual museum except as an academic exercise in cooperation.

Cooperative access models in the art museum and library community are closer to the union catalog approach of bibliographic databases, sharing a belief in common descriptive practices, including the consistent use of controlled vocabulary, as the basis for cooperative cataloging and access. However, Bower (1993), writing from the vantage point of the Getty AHIP, argues against the combination of individually created databases into a single resource because errors of ambiguity may be introduced. “Data that are unambiguous within the context of their initial capture . . . may become ambiguous when juxtaposed with data in different languages, data from other disciplines where overlapping terms have not been rendered referentially unique, or data from the same discipline that use different but equivalent terms to express names and concepts.”

And what of the solutions proposed by the library community for addressing the problem of integrating specimen data into museum records? Several recommendations were made that the MARC (Machine Readable Cataloging) format be used to describe museum objects, particularly given the development of the Archives and Manuscript Collections format and specific visual materials formats. Bierbaum (1990) suggests that museums and libraries are alike in creating surrogate records for objects in their collections but cautions that converting museum records to MARC may not go smoothly because of the lack of descriptive standards in the museum community. Reporting on the use of the MARC structure at Berkeley to provide access to a range of non-book collections, Besser and Snow (1990) present the mutually exclusive options of a specifically designed relational database and the existing MARC standard. They remind us that for every opportunity there is a corresponding obligation, noting that “the flexibility that one enjoys in a relational database management system avoids the stricture of the MARC structure that the bibliographic retrieval systems require, but one pays for that in lack of consistency and transportability.” Bearman (1989, 1990) speaks of the advantages of shared reference files and the development of generally useful thesauri, even though a union catalog of (almost) unique items does not have the economies of scale that a union catalog of print-based materials would have. To date, there have been a few experiments with using the MARC format as a vehicle for describing museum specimens, but they are considered novelties.

Proposed Data Models for Cooperative Access to Natural History Museum Information

While the rhetoric of network culture may imply that technology that enables cooperation will ensure that cooperation, such cooperation is not readily achieved. Nomenclatural differences, as well as differences in the database schema, that is, the selection of which data are collected and at what level of detail, have tended to balkanize developing biological databases (Williams, 1997). With the popularity of the Web as a mechanism for allowing access to specimen information and other collection data once maintained solely on institutional databases, more efficient handling of data in distributed repositories has become a major issue (Schatz, 1997). Proposed solutions include "automatic" generation of hyperlinks among "federated" databases (Jamison, Mills, & Schatz, 1996) as a means of relating conflicting names. Data discovery techniques used in data mining may also be used to help develop algorithms that enable the capture and use of historical data.

As expectation for access to these scattered data resources grows, such techniques as vocabulary switching have been proposed as a method to assure interoperability between nomenclatural systems. In bibliographic practice see and see also references are a type of vocabulary switching. This technique is used to preserve relationships between terms and make a user aware of additional subject terms or alternate forms of a name used in a catalog that they would have otherwise missed. Application of vocabulary switching techniques as discussed by Tillett (1991) could take advantage of existing relationships between alternate scientific names and allow the retention of older or inconsistent nomenclature.

Directories of Electronic Resources

One potentially valuable cooperative development along these lines is the recently announced project to develop directories of taxonomists and natural history collections available via the Internet. The National Biological Service has signed an agreement with the ASC to develop these directories, which will be available through the National Biological Information Infrastructure (NBII). The collection survey will include information on the status of collection information automation projects and hot links to those databases, when permitted. Given the proliferation of electronic records forming the publication base for such projects as the Flora North America project and other floristic projects arising from the research efforts coordinated by the Mis-

souri Botanical Garden, an undeniable need exists for a similar system of pointers to the location of this material. There is also a growing need for the documentation of collaborative projects, such as NATUREnet, wherein nine of the large U.S. natural science museums and two botanical gardens are exploring the possibilities of shared specimen records.

While adherence to a model similar to that of the bibliographic standards employed by libraries has been suggested, the systematics community has not adopted it. The union list concept of specific item-level holdings (e.g., of particular issues of a journal) to which individual libraries contribute according to mutually accepted standards does not have any serious followers. Instead the individual disciplines of natural history maintain their own specimen level information, usually on a per-museum basis. Information sharing consists of allowing access to individual searchable files maintained by a single museum or by periodically contributing information to an established discipline-based database. Since some manipulation of the contributed data is required to make it conform to the depository database, interactive updates of data are not easily done.

Community Standards

The publications of the ASC, particularly the *ASC Newsletter*, are perhaps the best indicator of the progress of the systematics community in arriving at a series of standards for description of specimen collections. The expectation that a standard for data exchange, even within a single scientific discipline, would emerge from endless working groups, such extensive self-studies as the MITRE report (Cooley, Harrington, & Lawrence, 1993), and admonitions from such theorists in the museum computer field as David Bearman has not materialized. In the August 1995 issue of the *ASC Newsletter*, which reported on a July 1995 symposium during the organization's annual meeting titled "Natural History Collections on the Information Superhighway," members were "challenged . . . to accept the concepts of shared databases and centralized software system development." If accepted, this concept would represent a major shift in the systematics community's approach to access to electronic specimen information. The development of "middleware" that would allow for the long-desired interoperability among autonomous systems continues to be discussed, with more systematists involved in the development of data models and controlled vocabulary lists. Other major concerns of the ASC computer and networking committee included the investigation of the

ability to publish information from combined databases and the development of shared authority files.

During the 1995 ASC annual meeting Stanwyn Shetler from the National Museum of Natural History, Smithsonian Institution, spoke on ASC's strategic planning goals. "The time is ripe for museums to usher in the Age of Access. If our generation doesn't figure out how to provide better access to the information stored on our existing collections, then the next generation may not be able to defend keeping these collections. This is a time to consolidate collections, electronically if not physically, and concentrate on improving access to their information, while focusing our future collecting efforts to address specific questions. We continue to amass collections faster than we can assimilate, curate and study them—to store far more information than we can retrieve—all on the assumption that we must fill the museums while we still can, so that some future generations, after everything is extinct, can sit in a sterile laboratory and study the specimens we never got to" (Shetler, 1995).

Behind the ongoing debate about cooperative access to specimen data is a growing concern about the retention of the specimens themselves. Arguments for "pulping the herbaria" and otherwise discarding specimen collections after recording the collections in some digitized form are countered by museum curators who persist in their belief that the physical object, along with its related literature, remains the validating evidence. The ASC's 1993 publication, *ASC Guidelines for Institutional Database Policies* (Hathway & Hoagland), specifically recommend that specimen collections, with their associated documentation, be retained even after the information about the specimen is captured in a systematic database or included in a published monograph. The principal argument for the retention of both specimens and their associated documentation is that errors in understanding and interpretation do occur. Specimens and their original and accumulated documentation should be retained as a means of resolving later conflicts of opinion.

Gateways and Cooperatives

While it is often the case that museum departments function with considerable autonomy within a given museum, curatorial staff are aware of the benefits of maintaining electronic data on collections consistent with developing standards in the museum community. There is value perceived in being conversant, if not necessarily compliant, with standards and practices in the intellec-

tual environment outside the institution. Agencies providing major grant funding, such as the National Science Foundation, increasingly require the ability to share electronic data of a museum's systematic collections as a prerequisite for consideration for further funding.

In 1996 the White House Subcommittee on Biodiversity and Ecosystem Dynamics, in recognizing the value of specimen collections, "identified systematics as a research priority that is fundamental to ecosystem management and biodiversity conservation" (Waggoner, 1997). The Integrated Taxonomic Information System (ITIS) is designed to support improvements in the organization of and access to standardized nomenclature. The success of ITIS, a component of the National Biological Information Infrastructure (<http://www.nbs.gov/nbii>), depends on the willingness of systematists to contribute taxonomic data on the biota of North America to the database. Systematists can support the NBII's primary objective, which is to increase access to distributed sources of biological data and information, by contributing metadata that describe their electronic collection data to the NBII clearinghouse. Users will search the NBII Metadata Clearinghouse to locate biological data from a distributed network of cooperating information sources and provide links to those individual sources.

The gateway approach used by the NBII initiative is similar to cooperative efforts rising from the academic and museum community. Given the difficulties discussed above in the area of inconsistent nomenclature and descriptive standards, most projects focus on identifying resources and providing access to diverse collections within a single institution. The Berkeley Museum Informatics project, officially begun in 1992, but with considerable preliminary activity dating back to 1987, was created to work with "faculty, collections managers, and curators to develop data models, system architectures and demonstration and production systems as bases for coordinated and integrated approaches to the application of information technology in museums and archives" (<http://www.mip.berkeley.edu/mip>). Through creating standards for shared access to accession records and catalog information, the project seeks to identify previously isolated collections and their associated information and make this information known and available to a multidisciplinary community.

The Biodiversity and Biological Collections Web server at the University of Kansas (<http://biodiversity.uno.edu>), originally the Biodiversity and Biological Collections Gopher at Cornell University, also serves as a clearinghouse,

identifying searchable resources of interest to systematists. Its MUSE project and the associated workshops in the early 1990s did much to build awareness of the opportunities to cooperate on the computerization of natural history collections.

Conclusion

Natural history museums serve the basic human need to collect, combined with the related goal of science to organize information. Individual scientific disciplines have developed separate organizational schemes with diverse nomenclatural and descriptive structures. Even given present technologies, inconsistencies cannot be resolved at the level of the individual specimen record, particularly in legacy data that are incomplete by contemporary standards. Current solutions to the access problem include creating clearinghouses that identify the existence of information on a particular topic, continuing discussions toward the development of multidisciplinary standards that specify core or essential data in a record, and agreeing on the use of metadata to define and describe the nature and content of information contained in these data sources. A valuable lesson to be learned from the experience of cooperative access to databased information is that every cooperative opportunity has the corresponding obligation to develop and maintain standards if the goal of interactive data interchange is to be achieved. In looking forward, we should also look back to the Smithsonian's G. Brown Goode (1895) who reminds us that "catalogs are the keys to the treasure-vaults of a museum."

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