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Inherent and Acquired Hazards in Museum Objects

Implications for Care and Use of Collections

Museum collections are sources of a variety of hazards that reflect the nature of the collections, as well as the history of their use and the efforts to preserve them against various agents of deterioration. Some hazards derive from the specimens or objects themselves. Other hazards have been acquired as a result of intentional or inadvertent modifications of materials before and/or after they become part of a collection.

A collection object may pose a danger to humans because it is an inherently hazardous material; for example, a fossil that contains gamma-emitting uranium progeny, a sample of the mercury ore cinnabar, or seeds from *Strychnos nux-vomica*, a source of strychnine. In these instances, the specimens or objects are hazardous without intervention. Other collection items may have been initially designed to be hazardous, with or without intent. A container of curare deliberately extracted from a plant for use as an arrow poison was intended to be hazardous. A musket ball, while designed as a trauma-producing missile rather than as means to induce lead poisoning, may still be toxic should a collector inhale dust from its decomposition products. There are numerous products of the past centuries that fit into one of these categories. Black powder was meant to be hazardous, but lead paint as an original finish on an architectural embellishment and the asbestos used as the reinforcing fiber in a modeling material were not intended to pose hazards. All three can become very dangerous as they age.

NPS conservator Toby Raphael uses a vacuum with a high-efficiency particulate air (HEPA) filter to remove dust from an arsenic-treated bearskin from President Theodore Roosevelt's home, Sagamore Hill National Historic Site (SAHI 7102). Photo courtesy Department of Conservation, Harpers Ferry Center, National Park Service.

An object or specimen may have acquired hazardous character as a result of a post-production modification by the culture that used it. An indigenous South American hunter may have applied curare to an arrow tip. While the sharp point poses an obvious risk of physical damage, the presence of the poison greatly increases the hazard posed by the weapon. An early-20th-century furrier preparing a bear skin rug for a hunter may have simply tanned the skin and recommended regular cleaning to keep it in good condition. The housekeeper in the hunter's home could have periodically treated the fur with a toxic solution available from taxidermists to keep the rug safe from insects or rodents. While there may have been a recognized risk to the person applying the solution, it is likely that no one assumed there would be a long-term risk when the treatment was dry. It would not have occurred to most people that children who frolicked on the rug, or the maid who took it outside to shake or beat it to remove dust would be exposed to arsenic from these activities. When the arrow became part of a museum collection, any knowledgeable anthropologist would have suspected the presence of the poison. When the rug became part of the collection in the historic home of the hunter, few museum staff would have suspected that cleaning the rug with a standard vacuum would pose a hazard to their health.

Some objects become hazardous through inadvertent exposure to hazardous materials. A photographic negative exposed to flood waters contaminated with raw sewage, or a pastel whose surface has been contaminated by asbestos fibers from decrepitating pipe insulation are examples of objects that can be salvaged, but cannot be completely decontaminated without causing further damage. Many collectors would be understandably reluctant to destroy these items, even if they could never be made "safe."

The primary concern of most collectors, whether private individuals or staff at collecting institutions, is preservation of their holdings. No matter what the impetus for the collecting may have been, loss of a collection translates to scientific, historic, educational, aesthetic, sentimental and/or financial loss. As a consequence, collectors have sometimes taken draconian measures to protect objects. It is only in fairly recent times that humidity, light, and gaseous pollutants have been recognized as potent agents of deterioration. In the past, the damage from these sources was often dismissed as the inevitable consequence of age. Damage from various disasters was not seen as preventable. However, the disfiguring effects of dust, rodents, and insects were obvious. Cleaning could take care of the dust problem, but it never truly solved the problem of pests. For centuries, the battle against pests has been the focus of collections care for organic materials. From the late-18th century until very recently, pesticides were perceived as the only successful means to prevent loss of these collections. Some of the residues of pesticide use have created long-lived hazards that are now well understood. The effects of others remain unknown.

One way or another, many of the objects and specimens that are now part of public trust collections, or are held in private hands, can pose some sort of hazard to anyone who cares for or uses them. The source of the hazards frequently has nothing to do with the current holders of collections, who may have simply inherited the hazards along with the collections. However, at least in North America, the individuals and institutions that house collections are perceived to have an ethical and, increasingly, a legal responsibility for the safety of the caretakers and the users of these resources.

Inherent Hazards

It is possible that archives and history and art collections are the main repositories of collection items that are hazardous by nature or design. After all, most plant, animal, and mineral materials in their native state are not hazardous to humans. That is the main reason they have been so useful to mankind. These, or moderate modifications of these, form the bulk of natural science and anthropological collections.

Archives and history and art collections reflect humankind's ability to greatly manipulate natural materials or to synthesize new materials for a host of purposes. These collections can include very complex objects. The origin, or even the presence, of some of the materials of which they are composed may not be easy to discern. The risks they offer may not have been recognized when the objects were created. For example, the inventors of safety film (acetate base film) never intended to design a chemical vapor hazard. They were, in fact, trying to eliminate the fire hazard inadvertently posed by celluloid (cellulose nitrate) films. Today, we have a fairly sound understanding of the hazards of both film types and know that there are preservation and safety strategies to minimize the risks.[1,2]

The hazards in art materials are most often discussed with an eye to protecting the artist, rather than collectors, because it is the artists who are at greatest risk.[3,4] The hazards in the finished product are often less than those from the products used in fabrication. The artist who created an artificial patina on a bronze sculpture would have been at risk if the patination solution contained chromic acid.[5] A collector who enjoys touching the bronze might pick up small amounts of chromium from the finish, but the exposure is likely to be very minor. For reasons that have nothing to do with personal safety, art museum staff would rarely handle a bronze with ungloved hands, reducing the risk dramatically. It would be naïve to assume that this kind of scenario is always the case. Certainly conservators, who use a variety of interventive treatments in their work, are exposed to hazards from these materials. There are times when a finished work can be quite hazardous to anyone. Some ceramic glazes and enameled jewelry in decorative arts collections contain uranium pigments that emit radioactivity measurable at some distance from the objects.[6]

Selected inherently hazardous items in history collections have been reviewed in publica-

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That, that is, is. (William Shakespeare, *Twelfth-Night*, Act IV, Scene ii.)

Research Assistant Michael Lambert enters well-labeled radioactive mineral storage area, Department of Geology, National Museums and Galleries of Wales, Cardiff. Photo by Barbara Cumberland, Department of Conservation, Harpers Ferry Center, National Park Service.

tions such as those on firearms and ordnance,[7] and pharmaceuticals.[8] At least one is now recognized as a result of new regulations—battery acids in transportation collections, which were never meant for long-term storage and now require secondary containment and spill control measures. Others, from radioisotopes in old medical equipment to cadmium sulfide coatings on photovoltaic cells, may be known, if less well publicized. Many are yet to be discovered. Some inherent hazards become dangerous via deterioration of their matrix, by decomposition of the material itself, or because the material is extremely stable over time. Was the yellow pigment used in the exfoliating paint on a decorated metal box formulated with orpiment (arsenic sulfide)? Was the iridescence in that inlay derived from mother of pearl, or from a synthetic pearl essence, possibly containing lead carbonate?[9] Are the crystals on that bottle with a decomposing seal from the acid in the bottle? Was that textile initially treated with a commercial mothproofing agent? To what degree do these pose a health hazard to anyone who works with or uses the objects? There really is no way to answer the last question without answers to those that precede it.

Anthropological holdings may have inherent hazards in the form of deliberately manufactured weapons or poisons, or perhaps because they incorporate potentially toxic minerals, metals, or other materials whose hazards may not have been understood when the objects were created. It is also possible that recently collected ethnographic items may be a source of biohazards, for instance anthrax on unprocessed wool, although this is likely to be rare.

In natural science collections, biohazards may be the most prevalent inherent hazards in recent vertebrate collections. Specimens from salvage operations or other collecting may host fleas or ticks that carry diseases, or blood-borne pathogens that are easily transferred to humans.[10,11,12,13] Cryogenic preservation could give these a long life in collections. In invertebrate and botany collections the inherent hazards are apt to arise from a toxic agent that may cause a reaction in humans that handle the specimens. Toxic minerals, especially those that have a friable nature, can be handling and inhalation hazards in geology collections.[14] Radiation hazards may also be present in geology collections, and are an ongoing problem in paleontology holdings.[15,16] Specimens containing iron sulfides in both collections can become handling hazards if the sulfides oxidize to produce acidic deterioration products.[17] Fortunately, as the cited literature attests, most of these problems have been the subject of research, and for at least two, hantavirus in biological specimens and radiation from paleontology specimens, there are published recommendations for safe practice.[18,19]

Acquired Hazards, Intentional Alterations

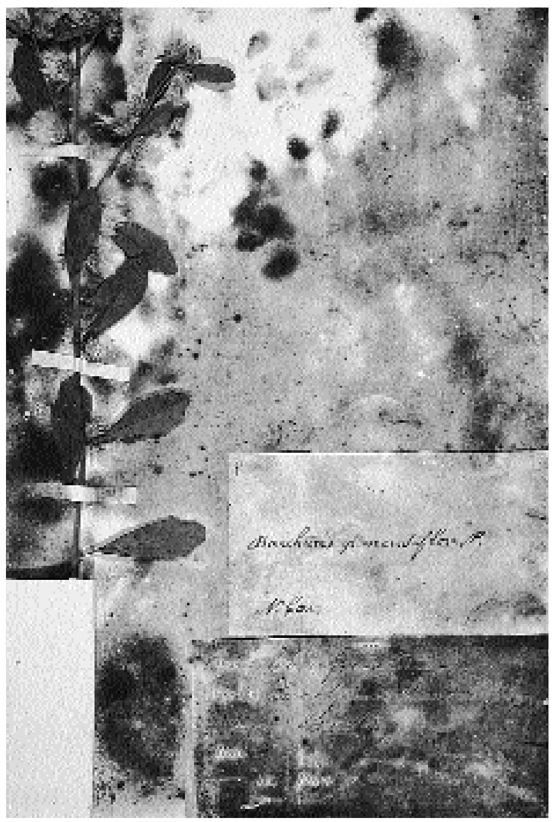
The main reason that large assemblages of organic materials exist in natural science and anthropological collections today is that natural historians in the late 1700s discovered that some poisons could protect these materials from pests, especially insect pests.[20] In 1748, a noted French naturalist lamented that collectors could see their collections daily destroyed by ravenous insects.[21] A great many early collections appear to have met this fate,[22] prompting an urgent need to find methods to mitigate the problem. The response was a host of publications that advocated the use of arsenic and/or mercury salts to stop the depredations.[23,24] Use of these chemicals continued for two centuries. Arsenic may seem to be a shocking choice to modern minds, but it was a widely available pesticide in the past, and its heavy use in collections was merely an extension of its use in other venues. In reality, the presence of arsenic residues poses few hazards that cannot be easily addressed during routine collections use. Mercury salt residues pose more serious problems because initially and through time, they are a persistent vapor hazard.[25]

The battle against pests continues to this day. Modern knowledge of insect life cycles and habitat requirements, improved environments in collections facilities, new storage and display case designs, and a desire to reduce reliance on chemicals in order to protect the global environment and human safety have resulted in new, generally non-chemical, methods of pest control. This does not mean that use of chemicals has been eliminated, merely that other methods are available. As author Hawks can attest, developing countries continue to use many highly toxic compounds, including mercury salts. Field biologists and collections staff anywhere may resort to chemical control when faced with massive infestations. The full array of pesticides used in the past may never be known completely, but surveys suggest that strychnine, hydrogen cyanide, carbon disulfide, boric acid, DDT, dichlorvos, ethylene oxide, methyl bromide, naphthalene, paradichlorobenzene, sulfuryl fluoride, lindane, and malathion are among those used with collections.[26,27,28] It should not be assumed that their use was limited to anthropology or biology collections. After all, archives, and art and history collections also contain organic materials.

I see it all perfectly; there are two possible situations—one can either do this or that. My honest opinion and my friendly advice is this: do it or do not do it—you will regret both. Søren Kierkegaard, *Either/Or*, Vol.2. (1843, transl.1987).

Of course, pesticides are not the only deliberate alterations of collections that may leave behind hazardous residues. In the geosciences, preparation of specimens by digesting the matrix with an acid can leave behind acid residues unless neutralized properly.[29] Author Hawks recently visited a collection where current staff noted that they had been burned by acid residues because of poor work by a past preparator. In the biological sciences, the number of different materials that have been used in preparation of dry specimens is remark-able.[30,31,32,33] Add to this the kinds of materials used in fluid-preserved collections[34,35] or microscopy preparations[36,37] and the number becomes staggering. The literature cited here is merely a brief introduction to what are, in effect, many thousands of publications on preparation methods. The hazards, if any, posed by the presence of most materials that may have been used in preparing or caring for collections is a largely unexplored topic.

The further problem in identifying hazards lies in understanding what may have been done to individual objects or specimens. There may be published techniques for various collections, but there are few records that link specific treatments to specific items. If we knew exactly what had happened to objects while in our own care, we might still be ignorant of treatments applied while they were on loan to others for research or exhibition. All of this has an impact on how collections can be handled safely, and on what types of uses they may still serve. A review of the extensive literature on the impact of pesticides on collections preservation is beyond the scope of this paper. A good discussion of the impact of various treatments on utility of some specimens for research and interpretation is found in Stephen Williams' text, *Destructive Preservation: A Review of the Effect of Standard Preservation Practices on the Future Use of Natural History Collections.*[38] What works to preserve a specimen or object for one use may well render it unfit for another.



Herbarium specimen with staining from mercury salt residues. Note: Staining is not always visible after mercury salt treatment. Photo by Catharine Hawks.

Despite this, our collected heritage continues to be used in ever more inventive ways.

Acquired Hazards, Unintentional Alterations

If the objects or specimens in a collection are not intrinsically hazardous and have never been intentionally treated with anything, this does not guarantee that they pose no risk. If the items sat in a storeroom where asbestos was released from a friable insulation, and then were moved to a new facility long before anyone suspected the problem, how would current caretakers know that the objects might be a safety hazard to themselves or anyone else? How would they even decide when to test? If these decisions are made and the tests show asbestos contamination, what happens when the object is a boat made of bundles of woven grasses or the specimens are a collection of soil core samples? Is decontamination possible? Objects sometimes become contaminated when they are housed in storage cabinets that previously held contaminated items. A recent survey revealed that mercury vapor from mineral specimens could be taken up by wooden cabinets and then released over time, long after removal of the minerals.[39]

You never know what is enough unless you know what is more than enough. William Blake, *The Marriage of Heaven and Hell,* "Proverbs of Hell"(1790-93).

When a rare book library has been exposed to prolonged high humidity or to flood water, mold infestations tend to follow. After the books have been dried and cleaned, do any mold spores remain? Of course, they do, but does this constitute a hazard to library patrons or staff? If recently collected biological specimens are attacked by pests, and the infestation is controlled by a non-chemical method, such as anoxia or freezing, is it possible to remove all traces of the insect frass that might otherwise trigger an allergic reaction? The best of fire protection does not always contravene human cupidity or stupidity, and either one can start a fire. Even if fire in a collection facility is extinguished before the collections are charred or melted, smoke may deposit soot on everything and the soot may have adsorbed or absorbed toxic residues from the burning of other materials. Again, removal of much of the soot may be possible, depending upon the objects to be cleaned, but complete removal may not be feasible. Perhaps one advantage in hazards from modern disasters is that we have learned that what we can't undo, we can at least record. Today, when collections staff know that something has been altered there may be documentation to that effect.

Inherited Responsibility

In less than 250 years, collectors have managed to bring together an incredible "cabinet of curiosities" that has helped illuminate the geology of our planet and that of its nearest neighbors in the solar system; displays the diversity of life on earth; and holds the thoughts, arts and industry of humankind. Nothing quite like it has ever existed before, it could never be assembled again, and it continues to grow. The uses we make of this remarkable resource may be constrained at times by the way it was created or cared for, but it can certainly be argued that these restraints are preferable to not having it at all.

Today, few collecting institutions or even private collectors are unaware that at least some of their holdings may be hazardous in some way. The specifics of which holdings and what hazards are still lacking, but at least a sense of caution exists and efforts are underway to air these issues through conferences and other forums. The University of Nebraska has a web page devoted to the problem of mercury vapor in its herbarium.[40] The National Park Service has collaborated with the Society for the Preservation of Natural History Collections on a proposed symposium on pesticide residues in collections. Staff at the Arizona State Museum organized a meeting with tribal groups to discuss the repatriation of potentially contaminated sacred objects. Instead of bemoaning the actions of past collectors who, after all, did the best they could with the limited tools and knowledge at their disposal, these organizations are taking positive steps toward making the best of our legacy.

While it is unlikely that we can ever fully mitigate the hazards, there is sufficient knowledge to make some educated guesses about what might merit testing and to adopt some prudent practices. Sadly, the simplest effective precaution seems to be the most difficult to implement widely—the use of gloves for handling objects or specimens. More sophisticated precautions probably warrant research before they can be deemed to be feasible. For example, author Makos has been monitoring mercury vapor concentrations in over a hundred storage cabinets, and the decrease in vapor concentrations when the cabinet doors are opened for specific amounts of time. These data will eventually allow anyone accessing this collection to follow a protocol to protect them from the vapor. Both authors are involved in developing a test strip that may be a reliable and inexpensive means to find out whether mercury vapor is a problem in a suspect collection. A researcher in Wales has explored concentrations of arsenic and mercury residues on herbarium sheets.[41] The more projects like

> *I don't believe in villains or heroes, only in right or wrong ways that individuals are taken, not by choice, but by necessity or by certain still uncomprehended influences in themselves, their circumstances and their antecedents.* Tennessee Williams, *New York Post* 17 March 1957.

these that are underway, the faster we can develop pragmatic approaches that reduce the risks from collection-based hazards.

Public health and environmental science resources for monitoring and evaluation of risk are available to many through their institution's insurance company, risk management firm, or the safety department in their university or state/local government. Often, these traditional safety offices have never been made aware of myriad potential hazards housed in collections. It will be up to the collecting institution to give them the information to begin the necessary monitoring and evaluation.

"Right to know" legislation charges us to make those who work with and use our collections as aware of the hazards as possible. The responsibility extends beyond the typical employer-employee training and includes transmitting information on potentially hazardous collection items that are shipped, and/or loaned, donated or repatriated to others. We need to move beyond regulatory requirements and take an ethical stance that makes furthering our understanding of the hazards a priority for all who hold collections.

Notes

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