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Storage and Handling of Poisoned Weapons in Museum Collections

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Master of Arts in Conservation of Cultural Heritage

by

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ABSTRACT OF THE THESIS

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The Fowler Museum at UCLA has several objects in their collection which are indicated in their catalog records as being poisonous, although there is little to no information about what poisons were used or whether they are still potent. The objects are currently stored with the rest of the museum's collection, often with no indication they may contain toxins. This thesis identifies housing solutions as well as storage and handling policies that can be implemented at the Fowler Museum to minimize the health and safety risks to those who might handle the objects. The Globally Harmonized System was used to create hazard labels for the objects. Fourier-transform infrared spectroscopy was investigated as a potential tool for identifying the presence of poisonous compounds on the objects, but was unsuccessful. Recommendations for future research and analysis are also identified.

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Introduction

Several African weapons in the Fowler Museum at UCLA's (hereafter the Fowler Museum) collection are indicated in their catalog records as being poisonous, although there is little to no information about what poisons were used or whether they are still potent. The poisonous objects come from different collections and were accessioned by the Fowler Museum between 1965 and 1999. Some of the poisoned arrows were found in storage in 2015 without any provenance, further complicating efforts to understand the history of the poisoned weapons at the museum. These weapons are currently stored with the rest of the museum's collection, sometimes with no indication that the object is poisonous. Previous research has found that although poisonous compounds break down over time, their byproducts can also be poisonous (Kubiatowicz 2008). Without proper labeling and housing, these objects pose a risk to the museum employees who handle them and researchers who might want to study them. Improving the storage and handling guidelines for these objects will ensure they can be accessed in such a way that those who handle them are safe.

Research Question

This thesis aims to identify best practices for the storage and handling of poison weapons, with a secondary goal of analyzing poisonous residues on objects in the Fowler Museum's collection to see if the poison is still identifiable and active. Since most of the weapons contain unidentified poisons, 'best practices' will be defined as storage and handling protocols that assume the poison is highly toxic and protect the user from any dangerous contact.

Methodology

First, a literature review was undertaken to see how other institutions have approached storage and handling of their hazardous collections. Then an item-level survey and review of museum records were undertaken to better understand the needs of the collection at the Fowler Museum. The survey identified the types of weapons present so that housing recommendations could be made for all the objects present in the collection. The survey was also used to identify the best candidates for sampling to see if any objects contained enough poison to be detected by FTIR. Further research was conducted to identify the best practices for storage and handling of poison weapons, including identifying proper Personal Protective Equipment (PPE) to be worn when handling such items. Proper storage protocols were also identified, such as whether the poison items should be mixed in with the rest of the collection or stored separately. Housing for the poison items was also researched to ensure there is minimal risk for transmission of the poisons.

Literature Review

Ethnobotanical Poisons in Africa

Many plants contain poisonous compounds that are hazardous to humans when ingested, inhaled, or absorbed through the skin. Depending on the type of plant and dosage of the poison, adverse effects can range from contact dermatitis to organ failure and even death. Toxic plant extracts have been used for hunting in Africa for centuries. Different poisons are used to hunt different animals, since each animal's system handles the poison differently. Many plant extracts used to make poisons also have medicinal uses and are safe for human consumption at lower doses. Alkaloids, glycosides, and terpenoids from plant extracts are the main toxic compounds in most poisons worldwide (Bradfield et al 2015). As shown in figure 1, use of arrow poisons in

Africa is generally restricted to the subtropical and tropical regions south of the Sahara Desert (Bisset 1989). A handful of poisons are monovalent and contain only one component, but most are polyvalent and consist of multiple materials. After being extracted from its source plant, the poison is often mixed with other components in order to help it adhere to the arrow or increase the efficacy of the poison (Bisset 1989).

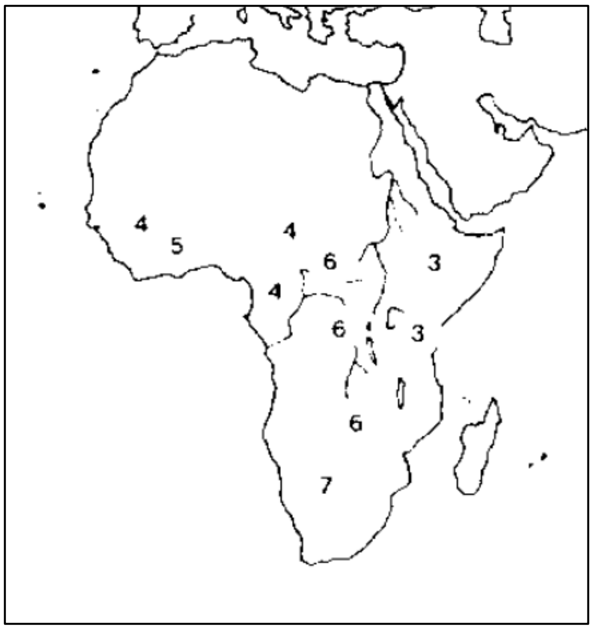

Figure 1: Distribution of the main arrow poisons used in Africa. 3: Acokanthera 4: Strophanthus, physostigma, erythrophloeum 5: Mansonia 6: Strychnos, erythrophloeum, strophanthus 7: Diamphidia. From Bisset 1989, Fig. 1.

Poisons Named in the Fowler Museum Database

Four poisons are named in the Fowler Museum's database: strychnos, farod, ngwono, and strophanthus. The information in the database appears to come from a variety of sources, including notes provided by the collectors. Other information provided in the database is more speculative and was likely added later by a curator or registrar.

The pantropical genus *Strychnos* is comprised of approximately 200 species and is divided geographically into three groups: Central and South American, Asia and Australia, and

Africa (Patoka 2015). The seeds and bark of many of the plants in the genus *Strychnos* contain the infamous and powerful poison strychnine (Figure 2), which has been used in arrow and dart poisons in many parts of the world (Bisset 1989). Strychnine is a neurotoxin that can cause respiratory and spinal paralysis, leading to death (Bowman and Rand 1980). Plants in this genus, however, are reported to have varying levels of toxicity (Bradfield et al. 2015). Geographic location appears to be a factor in toxicity. For example, *Strychnos spinosa* is widely used as a source of arrow poison in Central Africa, but the same plant grown in Florida did not contain any toxic compounds (Lofgren & Kinsley 1942). There are currently 75 known species of *Strychnos* plants found in Africa (Patoka 2015). *S. spinosa* is the most widely distributed and is found throughout tropical Africa. The root of *Strychnos icaja* is used in the Congo; it contains alkaloids and is similar to the poison curare used in South America (Bisset 1989).

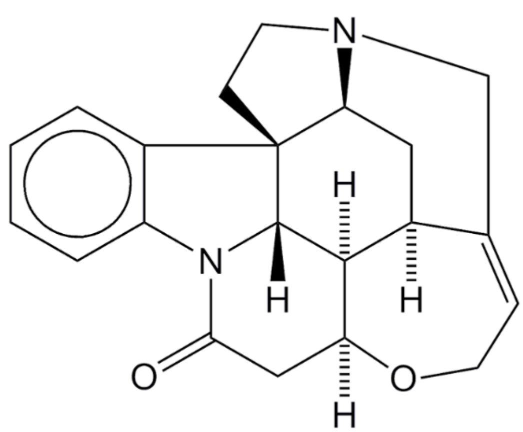

Figure 2: Chemical structure of strychnine. Image courtesy of the American Chemical Society https://www.acs.org/molecule-of-the-week/archive/s/strychnine.html

Strophanthus is the most widely used plant genus for poisons in Africa. Common species for making poison include *S. hispidus* in West Africa and *S. gratus* in Central Africa (Bisset 1989). The Ju|wasi and Zulu both used crushed seeds of *Strophanthus* plants, which have reported uses for hunting mammals and fish as well as use as a hallucinogen (Sobiecki 2002;

Neuwinger 2004). The seeds of *Strophanthus* plants are comprised of about 4% cardiac glycosides, such as strophanthin (Figure 3), which are highly toxic (Philipe & Angenot 2005). In low doses, cardiac glycosides are used to treat heart failure, but in larger doses they can cause arrhythmia and fibrillation (Bisset 1989).

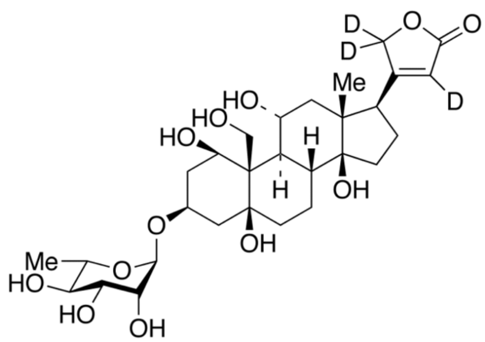

Figure 3: Chemical structure of g-strophanthin, also called ouabain. Image courtesy of Toronto Research Chemicals https://www.trc-canada.com/product-detail/?O714502

According to the Fowler database, farod comes from the getafarod tree and is used to hunt large animals such as buffalo or zebra. The getafarod tree is found near Mbulu, Tanzania and is similar to the baobab tree. The wood pulp of the tree is cooked for 12 hours until waxlike to make the poison. No other mentions of farod or getafarod have been found in literature, so this could be a local term for the tree that is not well-known. The museum database claimed ngwono was a poison used by the Pokot in Kenya, however it is also reported that the term ngwono is simply a synonym for poison and does not refer to a specific plant (Kipkore et al. 2014). There are also other potential poisons used in Africa that were applied to arrows but are not named in the database, including acokanthera, physostigma, and erythrophloeum (Bisset 1989).

Storage and Handling of Poisonous Weapons in Museums

Health and safety practices in museums have greatly improved in the last fifty years. For many decades, museum workers were exposed to toxic pesticides such as arsenic, mercuric chloride, and methyl bromide, which were applied to museum collections to prevent infestation (Goldberg 1996). The use of such toxic chemicals declined by the 1980s as awareness of their health effects increased, and in 1987 new regulations by the Occupational Health and Safety Administration (OSHA) required employees outside the manufacturing sector be informed about hazardous materials used in their line of work and receive safety training about them (National Park Service). The American Alliance of Museums (AAM) Code of Ethics, which was adopted in 1993, states that the governing authority of the museum must ensure that its staff receive adequate protection and training to do their jobs in support of the museum's mission. The American Institute for Conservation's Health & Safety Network began in 1998. Since then, network members have contributed numerous articles and guides for dealing with the various health hazards encountered by museum professionals (Ertel 2008; Hawks et al. 2010; French 2018), including hazardous collections. However, none of these publications have been focused specifically on ethnobotanical hazards.

Much research has been done into the proper storage and handling of objects that have had toxic pesticides applied to them to assist in preservation (Linnie et al. 1990; Odegaard and Sadongei 2005; Hawks and Makos 2014). Although there is a great deal of published information on ethnobotany and plant toxicology, there has been comparatively less research on how museums should store and handle objects that are inherently hazardous in nature, such as poisoned weapons. Each museum has different storage conditions, but it is often the case that objects are stored with minimally descriptive labels attached to them or no labels at all, with more detailed information accessible only through the museum database. This means that museum staff such as collections managers, conservators, and curators, as well as visiting researchers, can potentially be exposed to toxic materials in storage without having any clear and obvious warning. Staff at museums with poisonous collections materials have taken a variety of approaches to dealing with these objects. This includes restricting access to potentially poisonous objects, isolating this class of objects from the rest of the collection, tagging them with warning labels, and providing handling protocols that are stored within their museum databases.

The *Oh No! Ethnobotany* program at the Science Museum Minnesota was undertaken in the early 2000s to assist museums with establishing workplace policies and procedures that address safe handling and storage of toxic ethnobotanical collections in order to provide a safe work and research environment (Kubiatowicz 2003). Safety data sheets were created for a selection of poisonous materials found in the museum's collection. These ethnobotany material safety data sheets (EMSDS) are based on material safety data sheets (MSDS) and provide museum staff with relevant information on hazardous collection materials, such as the poisonous compounds in a material, the 50% lethal dose[1], first-aid measures, and the method of poisoning (such as skin contact or ingestion). The design for these EMSDS sheets was based on research by the Environmental Health Education Center at the University of Maryland that identified the best strategies for an effective hazard communication system (1997). Warnings containing a colorful icon were found to elicit the fastest response time. Further research by Kubiatowicz also found that objects can remain poisonous for several decades and in some cases even more than a century (2008).

The Royal Botanic Gardens, Kew took a different approach to their hazardous collections (Banks 2015). A survey was done of hazardous collections material to better understand the storage conditions and state of preservation of the specimens. The specimens were then grouped

[1] The 50% lethal dose, or LD50, is defined by the Canadian Centre for Occupational Health and Safety as "the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals" https://www.ccohs.ca/oshanswers/chemicals/ld50.html

into hazard categories based on the types of hazard present for each specimen (e.g. poison, glass, sharps). Risk ratings were then assigned to each hazard category for different types of handling (e.g. sampling, display) and color-coded according to risk, with red being high risk, yellow being intermediate, and green being lowest risk (Banks 2015). Grouping objects by type of hazard rather than by specific toxins could be a useful approach for museums with collections of unknown poisons.

Survey Design

An item-level survey of the objects identified as "poisonous" in the Fowler Museum's database was undertaken to get a better sense of the needs of the collection. The survey's main goal was to attain accurate measurements for each object and assess the current housing and poison labels to see what areas needed improvement. A secondary goal of the survey was to identify weapons with named poisons in their database descriptions and visible residues on their surface which could be sampled for FTIR. The survey was designed in Microsoft Excel because it was conducted entirely by the author and did not need to be accessed by multiple surveyors simultaneously. It included several fields to record information about the objects' storage location, current condition, size, composition, and catalog information. Each object's number was recorded, as well as any additional numbers from prior collection history. This was followed by a description of the object, its material composition based on visual analysis, and measurements of the length, height, and width of each object, in centimeters. The dimensions were each recorded in separate columns. The objects' storage locations within the museum were noted, as well as what type of storage they were currently in (drawer, shelf, or box). Information about the size of the current storage location was also recorded.

Each object was assigned a condition ranking of 1-4, with 1 being poorest condition and 4 being best. Condition 4 indicated that the object was in excellent condition, with minimal surface wear, no losses, structurally stable, and no conservation treatment needed beyond dusting. Condition 3 indicated the object was in good condition, there is some wear on surface, minor damage which does not affect stability of the object, and it may require minor conservation treatment. Condition 2 indicated the object was in fair condition, with moderate wear on surface, damage to structure but no active deterioration, and conservation treatment is needed but not urgent. Condition 1 indicated the object was in poor condition: one or more components of the object were unstable and actively deteriorating, and immediate conservation treatment was needed. The condition ranking was followed by an explanation of condition issues seen in each object.

Each object's current storage was evaluated based on whether the object was marked as poisonous and if so, if the label was adequate. An "adequate poison warning" provides warning to those accessing the collections that the object is toxic and also gives appropriate handling, safety, and toxicology information. Housing was also evaluated and determined whether it was adequate. "Adequate housing" is housing which facilitates safe handling and study of the object. It was also noted which objects contained visually detectable residues that could potentially be poisonous. Information from the museum database was also added to the survey in order to have all relevant information organized in one place. If the database mentioned a specific poison, it was listed in a separate column to be easily identified.

Survey Results

Of the 63 objects identified as poisonous in the collections database, 60 were surveyed. Three objects had been moved from their listed storage location and could not be located. Of the objects surveyed, none were in excellent condition, 26 were in good condition, 17 were in fair condition, and 17 were in poor condition (Figure 4). Forty-three percent of objects had a "poison" label on them, while 57% had no label. Of the objects labeled as poisonous, none were determined to have an adequate label. Some arrows had the word "poisonous" written on the shaft in red ink, but none of the labels included any handling guidelines. Ninety-three percent of objects surveyed have inadequate housing, while 7% have adequate housing. Fourteen of the objects have a specific poison listed in their database information, while 46 have no information on what poison might be present (Figure 5). Of the 14 objects with a named poison, 5 contain strychnos, 4 contain farod, 4 contain ngwono, and 1 contains strophanthus. Thirty-nine objects had some sort of surface residue which might contain poison, while 17 objects had no noticeable residues and 4 objects had arrowheads covered with plastic and therefore it could not be determined whether they had residues (Figure 6). Of the 39 objects with residues, 6 had a named poison in the catalog information.

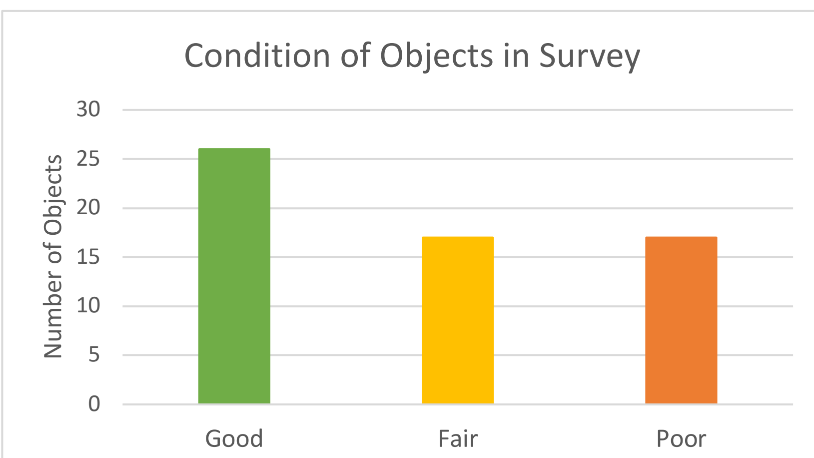

Figure 4: Graph of the conditions of surveyed objects.

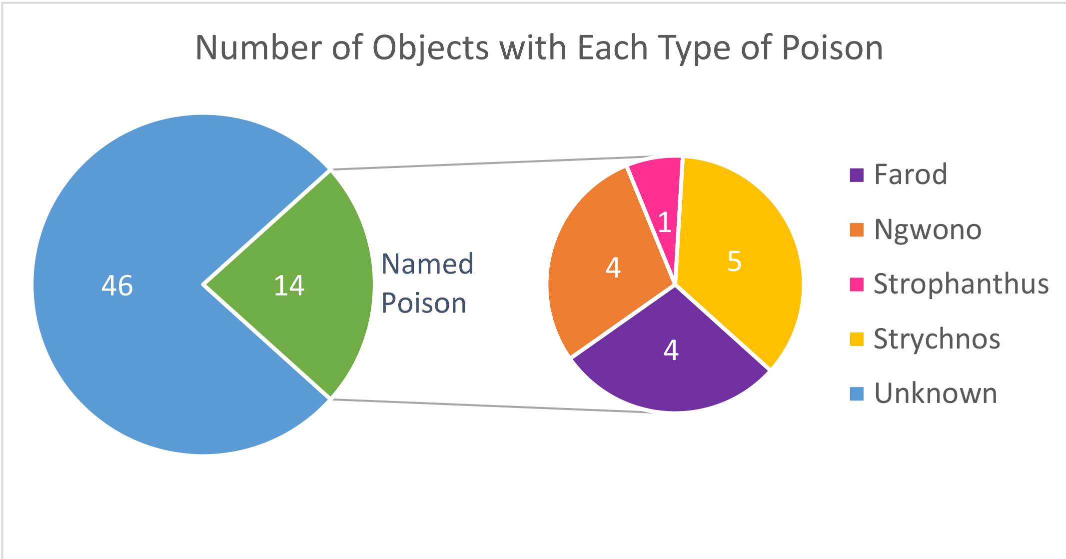

Figure 5: Chart showing number of objects with each type of poison.

Figure 6: Arrowheads wrapped in plastic and pressure-sensitive tape.

Housing Solutions

The majority of the poisoned weapons at the Fowler Museum are arrows. Six objects are described as darts but are similar in size to the arrows and therefore can be easily housed alongside them. Some of the arrows are currently loose in storage drawers, and some are stored in bundles inside quivers. Accessing the arrows in the quivers is difficult since there is a risk of damage every time the arrows are removed from the quivers. However, given the poisonous nature of the arrows it is unlikely that they will frequently be accessed. Storage inside the quiver takes up less space, something that is very precious in museum storage. In order to keep the storage footprint as small as possible, and because the quiver already provides a protective barrier for handling, the arrows inside the quivers can be considered low priority for rehousing unless circumstances change and they will need to be accessed more frequently. In order to minimize handling, the arrowheads which have been wrapped in plastic do not need to be unwrapped unless a compelling reason arises (e.g. for study).

The highest priority for rehousing are the arrows and darts not stored in quivers. Since the arrows are lightweight and relatively uniform in size, they lend themselves to a simple and straightforward housing solution. Storage boxes were selected as the best housing method for the arrows because they will keep the arrows completely enclosed, can fit several arrows in one box, and facilitate handling without having to touch the arrows themselves. The outer surface of the box will also provide a flat, even surface for attaching hazard labels discussed in the Policy Recommendations section.

A custom archival storage box was constructed from blueboard and hot glue with specific dimensions to ensure it fit inside a drawer in the Fowler Museum storage. The interior of the box was inspired by the arrow storage trays at the Kelsey Museum (Brown 1992). Two rows of Ethafoam were glued inside the box to provide support to the arrows while also giving room for the fletchings so they are not crushed. Arrows can be placed on the Ethafoam in a row and held in place with stainless steel pins covered with polyethylene medical tubing of an appropriate diameter. This method allows the arrows to easily be rearranged and for more arrows to be added in the future. The box lid was made with two windows covered with Mylar to allow people to see inside the box before they open it. The windows also allow for easier monitoring of the arrowheads and fletchings to ensure they are in stable condition. Modern archery arrows were used to make a mock-up of the arrow storage box (Figures 7 & 8). There are a total of 48 individual arrows and darts that need to be housed in boxes, which would require a total of 4 boxes to fit all the arrows.

Figure 7: Arrow storage box mock-up with modern archery arrows.

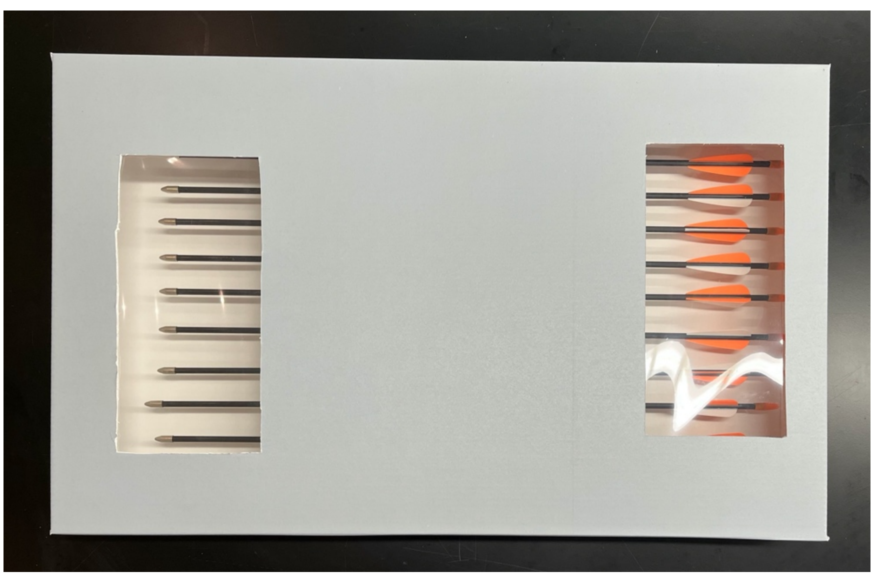

Figure 8: Arrow storage box with lid.

In addition to the individual arrows, there are three wooden plaques with multiple arrows mounted to them. These objects were found in storage in 2015 and have no provenance, so it is unknown when they were mounted and if the arrows are all from the same context. These mounted arrows are currently housed in zip close polyethylene bags. They should be rehoused in archival boxes similar to those made for the arrows to better facilitate safe handling, ideally with each plaque getting its own box.

There were three objects in the survey that were not arrows, darts, or quivers. These other objects are a feather pom-pom, a ceramic pot, and a carved strychnos shell. The feather pom-pom was erroneously included in the survey because its database entry included the term 'poison;' however, this object is not believed to contain ethnobotanical toxins and does not need to be included in the scope of these housing recommendations. The ceramic pot was used by the Pokot people, who live in modern-day Kenya and Uganda, for cooking poison. The vessel could still have poisonous residues inside and should be stored with the rest of the poisonous objects. The ceramic has thick walls and is quite heavy, so it might be difficult to construct a box that could support its weight. If a box is not a feasible housing solution, the vessel should be stored in a sealed polyethylene bag to prevent residues from contaminating the surrounding storage area. The strychnos shell was made by the Kuba or Kasai, who are located in what is now the Democratic Republic of the Congo. According to the museum database, the carved shell was hung from the hunter's belt and the arrow tips were dipped into the poison through a small hole at the top. The poison had an oily texture and was contained in a "spongey mass of grass." The entire shell has a reddish-brown, oily residue on the outside and the object is currently housed in a zip-close polyethylene bag. Based on the description in the database, the oily residue on the outer surface of the strychnos shell could contain poison. The object should be double-bagged to prevent residues from seeping through. Since the strychnos shell is round, a box or tray with Ethafoam supports is recommended to hold the object in place and further minimize direct handling. A drop-front box with a Mylar window, such as the one in figure 9, would provide a sturdy enclosure while also allowing easy viewing in storage and minimal handling (McGrew 2016).

Figure 9: Drop-front storage box. Image courtesy of Angela Yvarra McGrew, 2016.

Policy Recommendations

The Fowler Museum's storage and handling policies should ideally be simple and straightforward to avoid confusion. Since most of the objects do not have a specific poison identified in their description, it is difficult to ascertain the exact level of toxicity. The safest practice is therefore to assume all unidentified poisons are highly toxic and handle them accordingly. However, this approach does come with challenges since it becomes more difficult and time-consuming to access restricted materials. The poisonous compound strychnine, which is derived from the seeds of certain tress in the *Strychnos* genus, is used in some laboratory work and therefore has published safety data which can be useful as an example of how to handle a hazardous biotoxin. Proper PPE should be worn to prevent contact with skin or ingestion. This includes wearing a lab coat, Silver Shield® gloves[2], and closed-toed shoes (NIOSH, UTHSC). Silver Shield® gloves are made with five layers of high- and low-energy polymers and are

[2] Maggie Murphy, email message to author, February 22, 2023.

impervious to 280 hazardous chemicals, including 90% of all organic chemicals[3]. However, these gloves are much more expensive than regular nitrile gloves. If Silver Shield® gloves are outside the scope of a museum's budget, two layers of nitrile gloves should be worn (NIOSH, UTHSC). In addition to wearing gloves, those touching the objects should wash their hands thoroughly after handling and should avoid touching their face until their hands have been cleaned (UTHSC). Lab coats contaminated with strychnine should be washed before their next use. It should be noted that the strychnine used in a laboratory setting is most likely a very pure compound, which makes it more dangerous than the poisons at the museum which have often been mixed in with other materials and are more dilute. Poisonous objects should remain in their housing as much as possible, if they are removed from their housing they should not be left unattended. The objects should be returned to storage immediately after use and any workspaces wiped down three times with a solvent that dissolves organic matter, such as acetone, to ensure all traces of the organic compounds are removed.

Storage Location

Currently, the Fowler Museum's poisonous objects are dispersed throughout storage, some without any indication that they may potentially contain poison. It is recommended that a space in the storage area be designated specifically for intentionally poisoned objects. Storing all poisoned objects together will make it easier to post handling guidelines and other pertinent information. The storage area should be well-labeled so anyone who accesses it can easily see the hazard warnings. Grouping all poisonous materials together has the additional benefit of making staff and researchers aware that that they are working with hazardous materials. If the objects are mixed in with the rest of the collection, staff may treat them as any other object.

[3] Silver Shield is a registered trademark of Siebe North, Inc. Details about the gloves can be found on the Sigma-Aldrich website: https://www.sigmaaldrich.com/US/en/product/aldrich/z529567

People will be more cognizant that they are handling poisonous materials if they must go to a special location to access them. Another step that can be taken to ensure safe practices is to store the poisonous objects in a locked storage cabinet or room. Requiring someone to use a key to unlock a cabinet or room will remind them of the potential danger of these items and the need to follow special procedures. Untrained staff, volunteers, and researchers unable to access a key would also be protected from accidentally handling these objects without proper PPE.

Signage and Labels

The best way to ensure information stays with the object is to attach a label directly to the surface, as is often done with catalog numbers. Each arrow should be marked with a “POISON” label to warn those handling the objects. However, the shape and material composition of the arrows makes this task more complicated. Most of the arrows included in this study are made from plant material, which is sensitive to water and solvents. The adhesive used to attach the label to the object should be carefully selected, since many of the available options could be impossible to remove without causing damage to the object. Since many of the poisons are currently unidentified, labels should be completely reversible to allow for information to be updated if further research is conducted that changes the understanding of the objects’ toxicity.

One common labeling method is to apply a barrier layer to the surface of the object and then write the number in ink, sealing it with another layer of adhesive. However, the round and narrow shape of the arrow shafts would make it more difficult to handwrite the labels, and due to the hazardous nature of the objects it would be safer for museum staff to use a different method that minimizes that amount of direct contact needed with the object. In order to minimize handling of the arrows, laser-generated labels on archival paper are recommended. Laser printers use carbon-based ink with thermoplastic polymers which are thermally fused to the paper and will be stable long-term (Cassman et al. 2007). Century Gothic and Arial fonts in bold have been found to work well for object labels, using an appropriate size font for the size of the object (Cassman et al. 2007). The label can be adhered with Rhoplex B60-A[4], which is a water-based acrylic emulsion sold by suppliers of conservation products. The label can easily be removed in the future using either water or acetone. These paper labels should quickly and easily adhere to the shafts of the arrows.

Since the Pokot ceramic for cooking poison is low-fired, adhering a paper label may stain the surface no matter what adhesive is used. The vessel has one complete handle which could be used to attach a hazard label such as the one described later in this thesis. The label could be secured to the vessel's handle with cotton twill tape so the relevant safety information would remain associated with the object. Another option could be placing a hazard label inside the vessel, but it could easily become dissociated from the object. Since the strychnos shell is covered with an oily residue, a label should not be adhered to the surface. Once the object has been double-bagged, a hazard label should be attached to the outer bag and a second label should be attached to its box.

It is best to have duplicate information in multiple locations to ensure the information is accessible even if one method becomes unavailable. Hazard information should be added to each object's entry in the museum database. The poisoned objects' storage location should be marked with hazard labels and instructions on handling protocol including PPE recommendations. These labels should also be applied to the objects' housing, such as the arrow storage boxes described in the Housing Solutions section. This procedure should ensure those handling the objects encounter the information multiple times: they should first be notified when accessing the

[4] Rhoplex B60-A is an emulsion containing ethyl acrylate and methyl methacrylate. It is manufactured by the Rohm and Hass Company.

museum database to find the storage location of the object, then again when opening the storage cabinet and a third time when opening the storage box. Also, if one person pulls the objects from storage for someone else to handle at a desk, both individuals would still be informed of proper safety protocol since the information is posted multiple times, so there is less risk of the information not being passed along to all those who need it. At this time, none of the poisons have been positively identified on any of the arrows. In the future, if specific poisons are able to be identified, data sheets similar to those made by Kubiatowicz should be made for the known poisons (2003). These data sheets should be associated with the relevant objects in the museum's database and hard copies should also be available in a location that is easily accessible to someone handling the poisonous objects.

The Globally Harmonized System (GHS) of Classification and Labeling of Chemicals can be used to create hazard labels that are clear and easily recognizable. It was developed by the United Nations and has been implemented to some degree in over 70 countries as of 2021 (Russie 2021). The GHS provides "rules for classifying the hazards of chemical products" as well as "formatting for safety data sheets" and "content for label and SDSs" (CCOHS). It is hoped that using an internationally standardized system of hazard communication will mean that international visitors to the Fowler Museum's collections storage will also be able to easily understand the labels. There are six components of a GHS-compliant label:

1. Product identifiers
2. GHS Pictograms
3. Signal Words
4. Hazard Statements
5. Precautionary Statements
6. Supplier Identification

The components above were used to create hazard labels for the poison objects in the Fowler Museum's collection (Figure 10). Since these labels are too large to attach to the poison arrows, they can instead be attached to the arrow storage boxes, and the information can also be added to the objects' entries in the museum's database. The supplier identification component is not relevant to the Fowler Museum's poison labels and was omitted. Other components needed to be modified for the purpose of the labels. The product identifier should be a common term for the substance, but since the arrows contain unidentified poisons, the selected identifier was "Poison – unidentified." It is important to still put 'poison' as the first term so readers will immediately understand there is a serious hazard present.

GHS Pictograms are black and white symbols surrounded by a red diamond. They are intended to warn users about the hazards of a particular chemical and must be printed in color. It was determined that the poison labels should have multiple pictograms in order to cover the scope of hazards for a variety of potential poisons. In this case, the health hazard and skull and crossbones were selected for inclusion on the poison labels. The health hazard pictogram includes chemicals that are toxic to specific organs, and the skull and crossbones indicate a chemical is fatal or toxic.

The signal word indicates the severity of the hazard, with "danger" being more severe than "warning." Since the poisons are unknown, "danger" should be used as the signal word. Hazard statements are standardized phrases by the GHS that indicate the risk associated with a certain chemical. According to the GHS, if a mixture of chemicals has different levels of severity in their warnings, the less severe warnings can be omitted. Phrases for the poison labels were selected that indicated the possibility of risk to the user, including 'may be toxic if swallowed or in contact with skin' and 'may cause damage to organs.' The first phrase was modified to also include the risk of toxicity if the unidentified poison enters the bloodstream, since the poisons used on the arrow tips were typically meant to cause harm when absorbed by the bloodstream.

Precautionary statements are also standardized phrases by the GHS that tell the user what precautions to take when working with the hazard. The precautionary statements are directly associated to their respective hazard statements. Based on the hazard statements selected for the label, the appropriate precautionary statements would be 'Wear protective gloves/protective clothing' and 'IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.' Since the poisons would also be toxic if they entered the bloodstream through a cut or puncture wound, another statement should be added, 'IF POISON ENTERS BLOODSTREAM: Immediately call a POISON CENTER or doctor/physician.' The precautionary statement to wear protective clothing is probably too vague for museum staff who have access to a variety of PPE. The statement should be modified to indicate exactly what type of clothing is necessary, but will also depend on what materials are available at the Fowler Museum.

Danger! **POISON - UNIDENTIFIED** Danger!

May be toxic if swallowed, enters bloodstream, or in contact with skin. May cause damage to organs.

Wear Silver Shield gloves/lab coat/closed-toed shoes. Wipe down work area with acetone 3x after handling object. Wash hands immediately after removing gloves.

IF SWALLOWED/ENTERS BLOODSTREAM: Immediately call a POISON CENTER or doctor/physician.

Figure 10: GHS-inspired hazard label for poison objects.

Identification of Arrow Poisons

Spot Testing

Spot testing was considered as a possible tool to aid in determining if there was poison present on the objects. Unfortunately, this was ruled out as a practical identification method for multiple reasons. Spot tests would identify if a certain poisonous compound, such as an alkaloid or cardiac glycoside, was present in the sample. Since most of the objects do not have a named poison associated with them, it is not clear for what compounds an object should be tested. This could result in numerous spot tests being needed for each object to positively identify a poison. Since spot testing is a destructive method that requires removal of a sample, this could remove so much material from the surface that it significantly alters that object's appearance or leaves little to no remaining residue on the object. Some of the tests also require a sample size of 1 gram which would be a significant amount of sample material relative to the amount of residue on the arrowheads (NIJ 2000). In addition, many of the test reagents include harmful chemicals such as formaldehyde, chloroform, sulfuric acid, and lead acetate (NIJ 2000). Some people may not be comfortable exposing themselves to toxic chemicals in order to determine if the arrow samples contain poisons, particularly if the spot test reagents are even more harmful than the poisons they would be identifying. However, utilizing proper PPE and working in a fume hood would minimize the risks associated with these chemicals and could provide valuable information for those handling the objects in the future.

FTIR of Arrow Samples

Description of the Samples

The results of the survey were used to identify two arrows which had visible residues on their surfaces and had specific poisons named in their catalog descriptions. Sample A was taken from an arrow with an iron tip (X67.624), collected in Northern Nigeria. This arrow was previously in the Wellcome collection and said to be "probably poisoned with [a] species of Strophanthus" according to the object's catalog card. The arrow was coated with a dark, resinous material that also contains thin fibers (Figure 11a). Sample B was taken from a wooden arrow

(412.58) collected in the Ituri Forest in what is now the Democratic Republic of the Congo. According to the catalog card, this arrow was made by the Bambuti and usually contains Strychnos icaja baill. This arrow was coated with a light brown material which is dotted with specks of a darker material and also contains some thin fibers (Figure 11b).

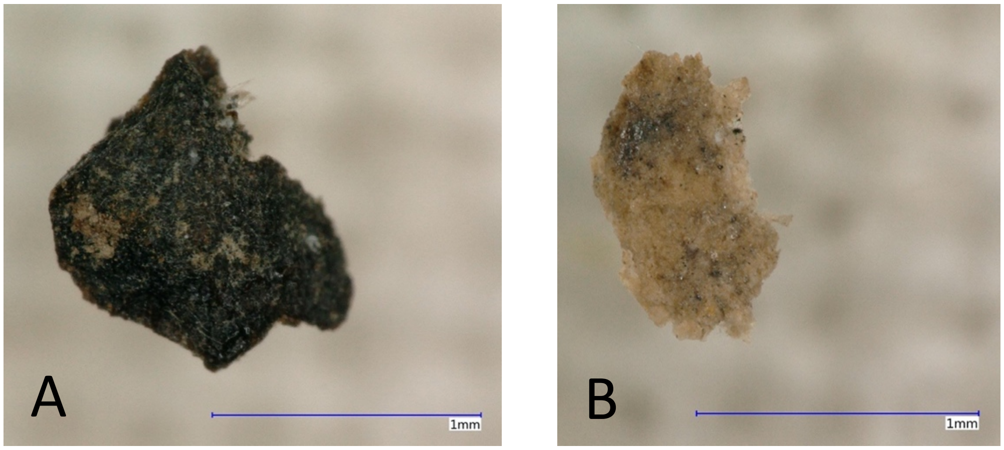

Figure 11: Photomicrographs taken with Keyence Digital Microscope 150x magnification. Sample A (X67.624) is darker and sample B (412.58) is lighter.

Background on FTIR

Infrared (IR) spectroscopy was first developed in the 1930s, and by the 1950s it had been widely adopted by laboratories as an important analytical technique. The Fourier transform is a mathematical procedure developed in the late 1700s which transforms a function of time into a function of frequency (Cheever 2022). In 1891, Lord Rayleigh published his findings on using the Fourier transform to convert output from an interferometer into a spectrum. However, due to the complexities of the calculations, the first use of Fourier-transform infrared spectroscopy (FTIR) did not occur until 1949 by astronomer Peter Fellgett. Advances in computer technology in the 1960s made the calculations faster and enabled FTIR to become commercially available. The technology was adopted by conservators beginning in the 1980s when the first commercial IR microspectrophotometers were introduced. [Derrick et al. 1999]

FTIR works by exposing a sample to a source of continuous infrared radiation and measuring the frequencies that pass through the sample to the detector. The radiation that is absorbed and transmitted by the sample depends on the molecules and bonds present, so different materials have different transmittance patterns and therefore give different spectra. Unless a reflectance FTIR is being used for data collection, a small sample (less than 0.5 mm) must be removed from the object for analysis. Typically when analyzing a solid sample with FTIR, it needs to first be ground into a fine powder in order to be properly analyzed. Attenuated Total Reflectance (ATR) allows for analysis of solid samples without the need for sample preparation. ATR uses a crystal to attenuate the energy from the sample so that a good quality spectrum can be obtained even with a thick sample (PerkinElmer 2005). Although it is less destructive than regular FTIR, the ATR crystal must be in good contact with the sample which means it will be under pressure and can deform or break apart if fragile.

Experimental Procedure

The Fowler Museum was looking for a straightforward and accessible method to identify if poisons were present. Previous studies used gas chromatography-mass spectrometry (GC-MS) and a synchrotron IR microscope to identify the presence of poisons in museum objects, but these methods were not easily accessible and therefore impractical for the Fowler Museum (Kubiatowicz 2008; Goodall et al. 2015). Instead, we decided to see if the samples had poison concentrations high enough to be detected with FTIR, because this technique was easily accessible to staff at the museum. Unfortunately, attempts to analyze the samples with an Agilent 4300 Handheld FTIR spectrometer in both absorbance and total reflectance mode were unsuccessful due to the small size of the samples and their fragility. Instead, the samples were saved and later analyzed with a Thermo Scientific™ Nicolet iS10 FTIR Spectrometer equipped with an ATR crystal. Spectra were obtained using 100 scans and a resolution of 4 cm^{-1}, with a wavenumber range of 4000 to 550 cm^{-1}. Thermo Scientific OMNIC software was used to collect and analyze the data.

Results

Both samples had very similar spectra, which was surprising given their different collection contexts (Figure 12). The main bands around 1027 cm^{-1}, together with other minor bands, indicate the presence of cellulose (as shown in Figure 13, by comparison with a reference spectrum of purified cellulose), which could be from woody material present in the object, a residue, or a conservation material such as methyl cellulose. Main bands at 1632 cm^{-1} and 1537 cm^{-1}, together with other less intense bands, are indicative of nylon (Figure 14). These results suggest that the residue on the arrows may have been previously consolidated with soluble nylon. Calaton CB (Figure 15) was a form of soluble nylon that was used by conservators in the 1960s and 70s as a consolidant (Sease 1981). A jar of Calaton CB from 1983 was found in the Arizona State Museum Conservation Laboratory and used as a reference sample. Attempts to solubilize the Calaton in ethanol were unsuccessful, likely due to the age of the Calaton which is known to crosslink as it ages and become insoluble (Sease 1981). Crystals of dry Calaton CB were analyzed with FTIR-ATR using the same settings as the arrow samples.

The wooden arrowhead on 412.58 could explain the presence of cellulose on sample B, but sample A had the same peaks even though it was from an iron arrowhead. Both samples appeared to contain thin fibers which could be from a plant material that was used to make the poison. Records for other arrows in the Fowler Museum's collection mention that the poison 'farod' was obtained by cooking the plant material for several hours until waxlike. If the preparation method for the sampled arrows was similar, the fibers could be remnants of the poisonous plants.

Since the intensity of the peaks is proportional to the material's concentration, FTIR was not able to detect the small amounts of poisons (if present) because of the broad and intense bands of nylon and cellulose. In addition, nylon was probably applied over the poisons (if present), making the possible application of FTIR for the identification even more challenging. The poisons' FTIR signals could be amplified using Synchrotron facilities which might allow such identification (Goodall et al 2015), but due to the limited availability of those facilities this is not a viable option for daily applications at the Fowler Museum. The difficulties of identifying potential poisons further highlight the importance and need for proper storage and handling protocols, since currently there is not a simple, non-invasive way for the poisons to be detected.

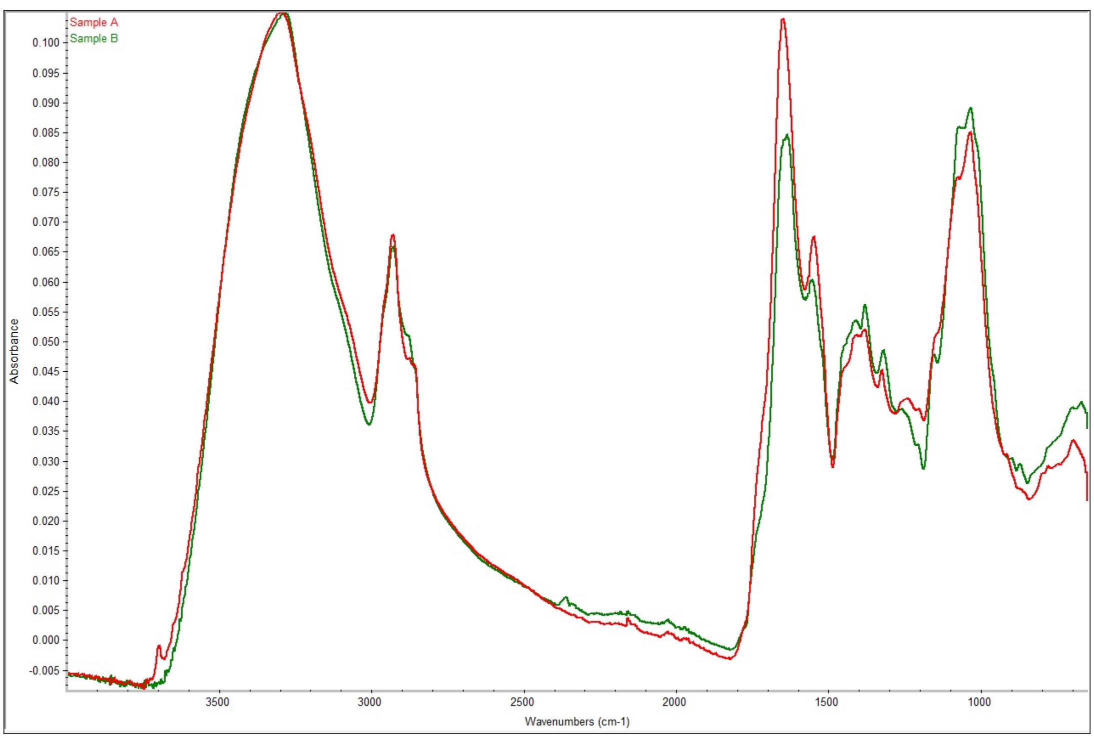

Figure 12: FTIR Spectra of Samples A and B.

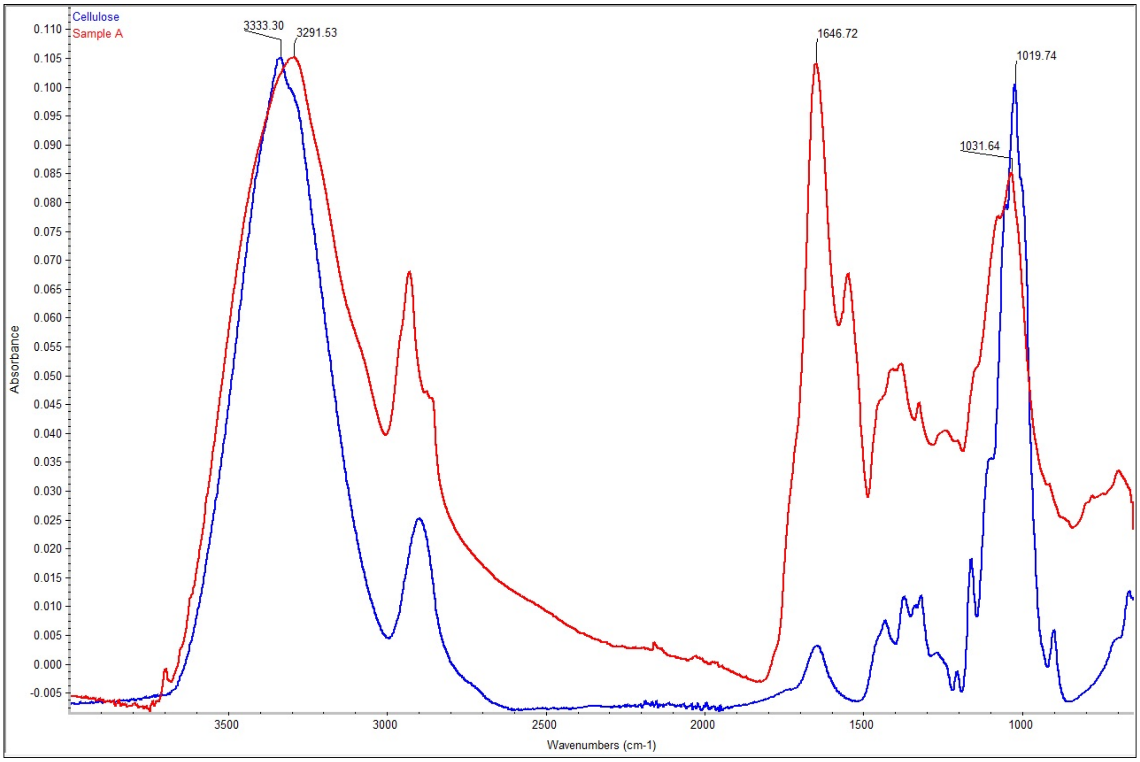

Figure 13: FTIR spectra of Sample A (red) with cellulose (blue) for comparison. Both spectra have peaks near 3333 and 1027 cm-1.

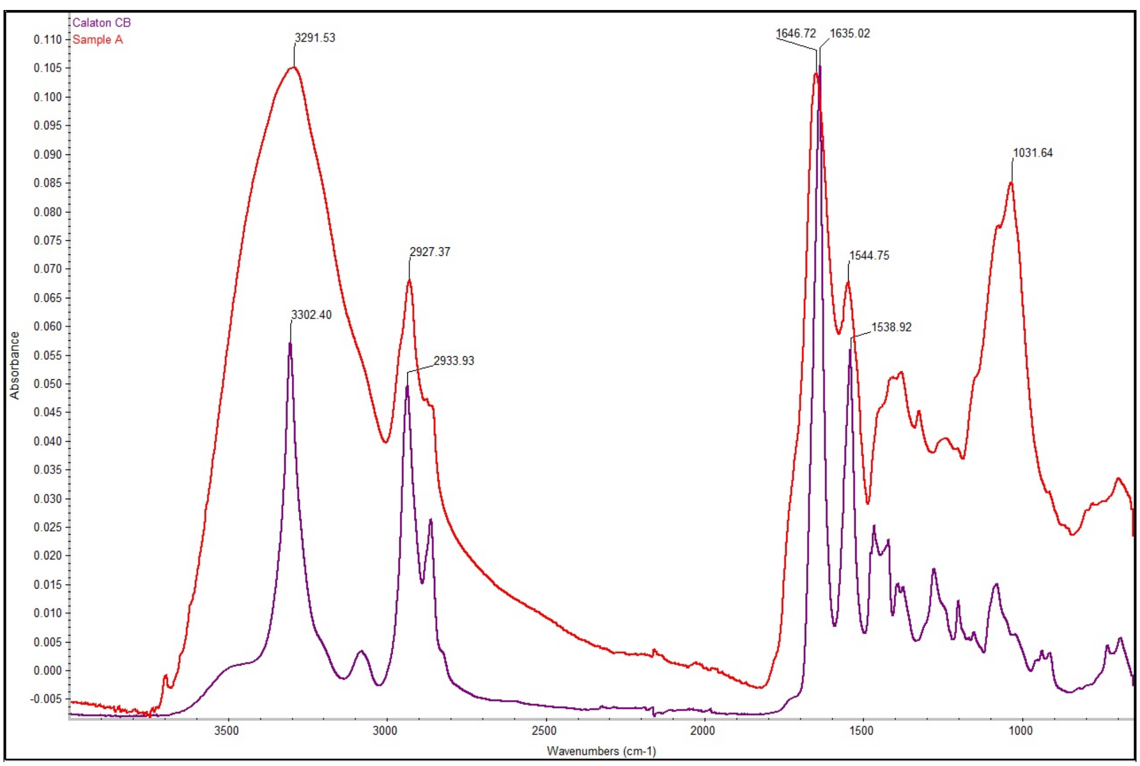

Figure 14: FTIR spectra of Sample A (red) with Calaton CB (purple) for comparison. Both spectra have peaks near 1632 and 1537 cm-1.

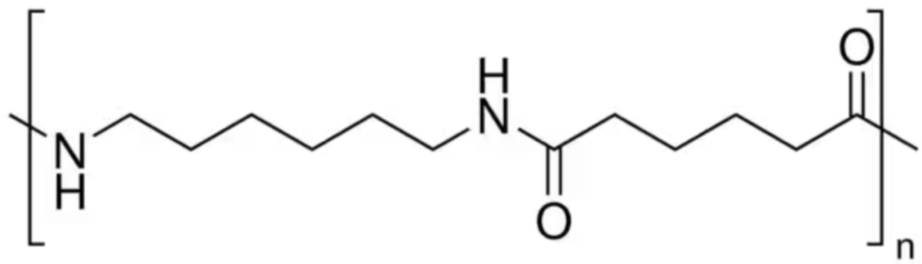

Figure 15: Chemical structure of nylon 6,6, which is reacted with formaldehyde to create Calaton CB. Source: Sigma-Aldrich.

Discussion

The storage and housing solutions proposed in this thesis attempt to provide museum staff with the knowledge and protection necessary to handle poison arrows. Of course, the best way to reduce risk of injury or illness is to minimize handling of the poison arrows as much as possible. Another consideration is the risk that these poison arrows pose in comparison to other items in the Fowler Museum's collection. Due to the long history of pesticide use in museums, many objects in the collection now contain harmful pesticides (such as mercury and arsenic) that also pose serious health risks. Mercury is a neurotoxin which can cause mood swings, organ failure, and even death at higher exposures (EPA). Arsenic is a carcinogen and can be toxic if swallowed or inhaled (NIOSH). Despite the health risks, these objects are still being displayed, studied, handled, and conserved. Are the poison arrows any more dangerous to humans than a textile which was treated with arsenic? It is difficult to compare the relative health risks of these different materials, especially when most of the poisons on the Fowler Museum's arrows have not been identified.

Further Work

Since FTIR was unable to identify if poisons are still present on the arrows, a more sensitive analytical technique is needed. Although more difficult to access, previous research has successfully used GC-MS to identify the presence of poisons on artifacts over 100 years old (Kubiatowicz 2008; Borgia et al 2017). Once specific poisons can be identified, safety data sheets similar to those made by Kubiatowicz can be made for each poison containing information on the health effects and toxicity (2003). The strychnos shell would be a good candidate for further analytical study because researchers would already have a specific poison (strychnine) in mind. Toxicologists should also be consulted to address whether the GHS labels can be downgraded to less severe warnings if the known poisons do not pose a significant health risk.

Conclusion

Several practical solutions for storing and handling poison arrows have been identified and recommended for the Fowler Museum. A survey of the poison materials in the museum's collection was essential for understanding the scope of what was needed in terms of storage space and the types of objects that needed rehousing. The housing process was able to be streamlined since the vast majority of the poisoned items are arrows which are similar in shape and size. Proper signage and labels in multiple locations are necessary to ensure all those who handle the arrows are informed about proper safety protocols. A modified version of the GHS was used to create poison labels to be attached to the arrow storage as well as the museum database. These labels inform users of the health risks, what PPE to use during handling, and what to do if they are exposed to the poison. Attempts to identify extant poisons on two of the arrowheads were unsuccessful, due in part to what is possibly an undocumented conservation treatment which added new material to the surface that is obscuring any poison signals from being read by the instrument. Although health and safety has become much more prominent in recent years, museum staff are still dealing with the consequences of decades of poorly documented and often hazardous museum practices. We hope that advances in analytical technology will allow for better and easier identification of the poisons on the arrows in the Fowler Museum's collection. Until then, extra precautions should be taken to ensure the health and safety of those who come into contact with these materials.

Appendix A: Survey Data

Fowler Object Number	Object Description	Materials	Drawer, Shelf, or Box	Condition (1 to 4)	Main condition issues	"Poison" label on object?	Is poison label adequate?	Current Housing	Is current housing adequate?	Type of poison	Visible residue which could be sampled
381.146	carved strychnos shell with metal belt clip	metal, string, strychnos shell, resin	drawer	3	Minor wear and surface damage	no	no	ziploc bag and paper snake	no	strychnos	yes, brown residue all over the surface
382.238	arrow made from plant material with feather fletching, nock, metal barbed arrowhead with brown accretion	plant material, feather, metal, plant fiber, unknown resin	box	2	accretion on metal tip is cracked and looks poorly adhered to surface, misaligned feather barbs	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.240	arrow made from plant material with feather fletching, nock, metal barbed arrowhead with brown accretion	plant material, feather, metal, plant fiber, unknown resin	box	1	accretion on metal arrowhead is cracked and falling off	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.241	arrow made from plant material with nock, feather fletching, barbed metal tip with thick tan accretions	plant material, feather, metal, plant fiber, unknown resin	box	2	plant fiber cord near fletching is coming loose, cracks in accretion on arrowhead	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.242	arrow made from plant material with nock, feather fletching, barbed metal tip with thick tan accretions	plant material, metal, feather, plant fiber, unknown resin	box	2	accretion on metal tip is cracked and looks poorly adhered to surface, misaligned feather barbs	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.243	arrow made from plant material with nock, feather fletching (light and dark brown feathers), metal barbed arrowhead	Plant material, metal, feather, plant fiber, resin	box	1	metal spiral where arrowhead is attached to the shaft is loose, accretion on arrowhead is flaking off	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead

382.244	arrow with nock, made from plant material with feather fletching and metal barbed arrowhead with brown accretion on surface	plant material, feather, metal, plant fiber, unknown resin	box	3	some cracking in the accretion on arrowhead	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.245	arrow made from plant material with nock, feather fletching. Barbed metal arrowhead with dull tip. There is an accretion on the arrowhead that appears to be some sort of resin mixed with plant fibers	plant materia, metal, feather, plant fiber, resin	box	1	loose piece of feather at risk of detaching, arrowhead residue is flaking	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.246	arrow made from plant material with nock, feather fletching, barbed metal tip with thick black accretions	plant materia, metal, feather, plant fiber, resin	box	3	cracking in accretion on arrowhead but it doesn't appear to be flaking off	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick black residue on arrowhead
382.247	arrow made from plant material with fletching made from dark brown feathers with white spots. Metal barbed arrowhead. Nock	plant material, metal, feather, plant fiber, unknown residue	box	2	misaligned feather barbs, cracks in arrowhead residue	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick tan residue on surface of arrowhead
382.248	arrow made from plant material with nock, feather fletching, barbed metal arrowead with rounded tip, whitish-beige accretion on arrowhead	plant material, feather, metal, plant fiber, unknown resin	box	2	accretion on metal tip is cracked and looks poorly adhered to surface, misaligned feather barbs	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick whitish-tan accretion on arrowhead

382.249	arrow made from plant material with feather fletching, nock, metal barbed arrowhead with brown accretion	plant material, feather, metal, plant fiber, unknown resin	box	2	cracking in accretion on arrowhead with minor flaking	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.250	arrow made from plant material with feather fletching (brown and yellow feathers), nock, metal barbed arrowhead with brown accretion	plant material, feather, metal, plant fiber, unknown resin, cord	box	3	cracking in accretion on arrowhead but it doesn't appear to be flaking off	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.251	arrow with feather fletching and metal barbed arrowhead	plant material, metal, feather, plant fiber cord, resin	drawer	3	Minor wear and surface damage	yes	no	supported with ethafoam blocks, metal tip encased in plastic tube	yes		yes, dark brown residue on metal arrowhead
382.252	arrow made from plant material with nock, feather fletching, barbed metal arrowhead with rounded tip covered in thick accretion	plant material, metal, feather, plant fiber, resin	box	1	loose feathers at risk of detaching or breaking	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.253	arrow made from plant material with nock, feather fletching, barbed metal arrowhead with rounded tip with thick accretion on arrowhead	plant material, feather, metal, plant fiber, unknown resin	box	3	cracking in accretion on arrowhead but it doesn't appear to be flaking off	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, thick brown residue on arrowhead
382.254	arrow made from plant material with feather fletching, nock, barbed arrowhead. Making tape wrapped around shaft	plant material, feather, plant fiber, metal, thread	box	3	feather barbs out of alignment	no	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, dark brown residue below arrowhead

412.53	arrow which likely used to have leaf fletching but it has since been lost (no metal arrowhead), slightly curved shaft	plant material, leaf	drawer	3	Minor wear and surface damage	no	no	tied in bundle with other arrows using twill tape	yes	strychnos icaja	no
412.54	arrow with leaf fletching, pointed tip (no metal arrowhead)	plant material, leaf	drawer	1	rehouse to protect extremely fragile leaf fletching	no	no	tied in bundle with other arrows using twill tape	no	strychnos icaja	possibly - there is a deposit on the arrow tip which is darker than the shaft
412.55	arrow with leaf fletching, pointed tip (no metal arrowhead)	plant material, leaf	drawer	1	rehouse to protect extremely fragile leaf fletching	no	no	tied in bundle with other arrows using twill tape	no	strychnos icaja	yes, whitish-brown residue on arrow tip
412.56	arrow which likely used to have leaf fletching but it has since been almost entirely lost (no metal arrowhead)	plant material, leaf	drawer	1	rehouse to protect extremely fragile leaf fletching	no	no	tied in bundle with other arrows using twill tape	no	strychnos icaja	yes, whitish-brown residue on arrow tip
412.57	arrow with leaf fletching, pointed tip (no metal arrowhead)	plant material, leaf	drawer	1	rehouse to protect extremely fragile leaf fletching	no	no	tied in bundle with other arrows using twill tape	no	strychnos icaja	no
412.58	arrow which likely used to have leaf fletching but it has since been lost	plant material	drawer	3	Minor wear and surface damage	no	no	tied in bundle with other arrows using twill tape	yes	strychnos icaja	yes, whitish brown residue on arrow tip

X2015.1.5	19 arrows mounted on rounded piece of wood with wire. 15 of the arrows are complete, the rest have broken off at the shaft. The arrowheads have a variety of different shapes but all are barbed. There are two old tags attached to the arrows, one is still legible but the other tag is broken.	wood, cane, metal, plant material, wire, iron	drawer	2	One of the arrows has completely detached from the wooden support and 2 others are loose. There is corrosion on all of the metal arrowheads. The plant material securing the arrowhead to the shaft is starting to break and unravel on 14 of the arrows	yes	no	ziploc bag	no		no
X2015.1.6	13 arrows mounted with wire on a piece of wood shaped like a shield. The shield has a metal hook on the back, possibly for hanging. 11 of the arrows are complete and 2 have broken off at the shaft. The arrowheads have a variety of shapes, some are long and pointed while others have a round ed tip with several barbs.	wood, cane, metal, plant material, wire, iron	drawer	2	One of the arrow shafts has broken off towards the bottom and this arrow is loosely attached to the wooden support as a result. Surface grime/dust on wooden shield.	yes	no	ziploc bag	no		some arrowheads have a white accretion present, all arrowheads have a dark brown fibrous substance on them

X2015.1.7	25 arrows mounted onto thin piece of trapezoid-shaped wood with thread. Many of the arrows have incised linear designs on their shafts. Most of the arrows have leaf fletchings. There is a single loose feather sitting on the object. The arrowheads have a variety of shapes and sizes, some have very small pointed barbed tips and others have triangular tips without barbs.	wood, plant material, leaf, feather, metal, thread, iron	drawer	2	ziploc bag is putting pressure on the fragile leaf fletchings. The thread attaching the arrows to the wooden board has broken at the bottom attachment site for 2 arrows	yes	no	ziploc bag	no		some arrowheads have a dark brown fibrous substance on them
X64.242.1	arrow made from plant material, no nock, masking tape wrapped around shaft. Metal arrowhead was removed and stored separately. Arrowhead has long shaft with barbs, pointed tip.	plant material, metal	box	3	remove masking tape from shaft	yes	no	shaft is inside box and tied to shaft of X64.242.2. Tip is wrapped in foam	no		no
X64.242.1	arrow made from plant material, no nock, masking tape wrapped around shaft. Metal arrowhead was removed and stored separately. Arrowhead has long shaft with barbs, pointed tip.	plant material, metal	box	3	remove masking tape from shaft	yes	no	shaft is inside box and tied to shaft of X64.242.1. Tip is wrapped in foam	no		no

X64.243.1	dart with barbed metal tip	metal, plant material, plant fiber	drawer	3	Minor wear and surface damage	yes	no	wrapped in foam secured with twill tape along with X64.243.1-6. Storage drawer has 2 layers separated by foam, this is on the top layer	no		no
X64.243.2	dart with barbed metal tip	metal, plant material, plant fiber	drawer	3	Minor wear and surface damage	yes	no	Same as X64.243.1	no		no
X64.243.3	dart with barbed metal tip	metal, plant material, plant fiber	drawer	1	accretion on metal tip (possibly poisonous) is flaking off the surface	yes	no	Same as X64.243.1	no		yes, dark brown residue on metal arrowhead
X64.243.4	dart with metal tip and broken shaft	metal, plant material, paint, plant fiber	drawer	1	accretion on metal tip (possibly poisonous) is flaking off the surface	yes	no	Same as X64.243.1	no		yes, dark brown residue on metal arrowhead
X64.243.5	barbed metal dart tip with plant fiber wrapped around shaft	metal, plant fiber	drawer	1	accretion on metal tip (possibly poisonous) is flaking off the surface	yes	no	Same as X64.243.1	no		yes, dark brown residue on metal arrowhead
X64.243.6	barbed metal dart tip	metal	drawer	1	accretion on metal tip (possibly poisonous) is flaking off the surface	yes	no	Same as X64.243.1	no		yes, dark brown residue on metal arrowhead
X64.244.1	arrow made from plant material with feather fletching, nock, metal barbed arrowhead	plant material, feather, metal, plant fiber, poison	box	1	feather barbs unstable and at rick of detaching	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, brown residue on arrowhead
X64.244.2	arrow made from plant material with feather fletching, nock, metal barbed arrowhead	plant material, feather, metal, plant fiber, poison	box	1	part of the feather fletching is very unstable and at risk of detaching	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, brown residue on arrowhead
X64.244.3	arrow made from plant material with fletching made from thick feathers, half of the nock is missing, metal barbed arrowhead	plant material, feathers, metal, plant fiber, poison	box	3	misaligned feather barbs	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, brown and light tan residues on surface

X64.244.5	arrow made from plant material with fletching made from thick feathers (light brown and dark brown), nock, metal barbed arrowhead	plant material, feathers, metal, plant fiber, poison	box	3	some misaligned feather barbs	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, light tan residue on arrowhead
X64.244.6	arrow made from plant material with feather fletching, nock, metal barbed arrowhead	plant material, feather, metal, plant fiber, poison	box	1	feathers in fletching are unstable and at risk of breaking or detaching. Cord around arrowhead is coming loose.	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, light tan residue on arrowhead
X64.244.7	arrow made from plant material with feather fletching and metal barbed arrowhead	plant material, metal, feather, plant fiber, poison	box	3	feather barbs out of alignment	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no - access difficult		yes, brown residue on arrowhead
X65.12539	arrow with metal pointed arrowhead with 2 barbs	cane, metal, resin, tape	drawer	3	remove tape if not original	no	no	tied in bundle with other arrows using twill tape	no		no
X65.12540	arrow with metal pointed arrowhead with 2 barbs	cane, metal, resin, tape	drawer	3	remove tape if not original	no	no	tied in bundle with other arrows using twill tape	no		no
X65.12671A	arrow made from plant material with pointed tip, no nock	plant material, poison	box	3	thick residue on tip is cracking	no	no	tied with twill tape to X65.12671B, arrow supported with foam	no - access difficult		yes, brown residue on tip
X65.12671B	arrow made from plant material with pointed tip, no nock	plant material, poison	box	3	thick residue on tip is cracking	no	no	tied with twill tape to X65.12671A, arrow supported with foam	no - access difficult		yes, brown residue on tip

X65.5874	arrow made from plant material with feather fletching, nock, metal triangular arrowhead, dark residue on shaft below arrowhead, dark residue where fletching is attached to shaft	plant material, metal, feather, plant fiber, resin, poison	box	1	residue below arrowhead is flaking	yes	no	arrowhead wrapped in tissue paper, arrow supported with foam	no		yes, dark brown residue on shaft below arrowhead
X67.624	arrow with metal single barb arrowhead	plant material, iron, plant fiber, resin, plaster	drawer	3	Minor wear and surface damage	no	no	none	no	strophant hus	yes, dark brown residue on metal arrowhead
X74.520	arrow with feather fletching	wood, feather, metal, plant fiber, gum, dye	shelf	2	needs rehousing to protect feather fletching	yes	no	arrowhead wrapped in plastic and paper secured with tape (old and yellowed) along with X74.521	no	Ngwono	unclear- arrowhead covered by plastic
X74.521	arrow with feather fletching	wood, feather, metal, plant fiber, gum, dye	shelf	2	needs rehousing to protect feather fletching, misaligned barbs	yes	no	arrowhead wrapped in plastic and paper secured with tape (old and yellowed) along with X74.520	no	Ngwono	unclear- arrowhead covered by plastic
X74.575	heavy ceramic pot with handles near rim, one handle broken, plant fiber straps wrapped around the pot	ceramic, plant fiber	shelf	2	needs rehousing to protect plant material straps	no	no	snake wrapped around base	no		no
X74.660	feather pom pom	ostrich feather barbs, tape, string	drawer	3	remove yellow tape if not original	no	no	ziploc bag	no		no

X74.865	Arrow made from plant material with feather fletchings	wood, feather, metal, thread, gum	drawer	2	old tape on arrow shaft, bent and misaligned feather barbs	yes	no	inside polyethylene envelope, taped to X74.866. Both arrowheads are wrapped in plastic secured with old, yellow tape. No support for feather fletching is causing distortion of barbs	no	Ngwono	unclear- arrowhead covered by plastic
X74.866	Arrow made from plant material with feather fletchings	plant material, feather, metal, thread	drawer	2	old tape on arrow shaft, bent and misaligned feather barbs	yes	no	inside polyethylene envelope, taped to X74.865. Both arrowheads are wrapped in plastic secured with old, yellow tape. No support for feather fletching is causing distortion of barbs	no	Ngwono	unclear- arrowhead covered by plastic
X85.191B	Arrow with oval shaped metal tip and feather fletching	wood, eagle feathers, metal, thread, resin, sinew	shelf	3	misaligned feather barbs	no	no	Housed inside quiver X85.191A with arrows X85.191B-E. Arrows are wrapped in soft Tyvek. X85.191F is attached to outside of quiver. Total dimensions L 100 cm x W 9.5 cm x H 7 cm.	no	farod	no
X85.191C	Arrow with single barb metal arrowhead and feather fletching	wood, eagle feathers, metal, thread, resin, sinew	shelf	3	misaligned feather barbs	no	no	Same as X85.191B	no	farod	no

X85.191D	Arrow with barbed metal arrowhead and feather fletching	wood, eagle feathers, metal, thread, resin, sinew	shelf	3	misaligned feather barbs	no	no	Same as X85.191B	no	farod	no
X85.191E	Arrow with rounded metal arrowhead with 9 barbs and feather fletching	wood, eagle feathers, metal, thread, resin, sinew	shelf	3	misaligned feather barbs	no	no	Same as X85.191B	no	farod	no
X99.1.43A	cylindrical arrow quiver with strap	leather, sinew	box	2	insect casings found on lid means there are probably casings in the quiver as well. Some surface discoloration/staining	yes	no	inside large ziploc bag, sitting on tissue paper in box	no		no
X99.1.43B	quiver lid	leather, sinew	box	2	insect casings inside lid, most likely old, leather separating due to broken threads	yes	no	inside large ziploc bag, on quiver	yes		no
X99.1.43C	bundle of 15 arrows made from plant material with nocks, feather fletching, metal arrowheads most of which are wrapped in strips of animal hide	plant material, feather, hide, plant fiber, metal	box	1	some arrowheads are detached from the arrows or held together only by the hide strips, misaligned feather barbs, hide strips are unraveling on some arrows	yes	no	large ziploc bag, formerly inside quiver X99.1.43A	no		yes, dark brown residue on some arrohead shafts

X99.1.65B	group of 15 arrows made from plant material, nocks, feather fletching, area where fletching is attached to the shaft was painted red barbed metal arrowheads of varying shapes and sizes, some are triangular with barbs, others are pointed ovals with barbs, many of the arrowheads are wrapped in hide strips	plant material, feather, paint, metal, hide, wire	box	2	arrows not labeled, misaligned feather barbs, some of the hide strips are unraveling, metal wire around shafts is unraveling	no	no	inside quiver X99.1.65A	no		yes, dark brown material on the visible arrowheads and shafts

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