

8-2018

Toxins in the Collection: Museum Awareness and Protection

Nellie Slocum

slocumne01@mail.buffalostate.edu

Advisor

Noelle Wiedemer

First Reader

Noelle Wiedemer

Second Reader

Dr. Cynthia Conides

Department Chair

Andrew D. Nicholls, Ph.D., Chair and Professor of History

Recommended Citation

Slocum, Nellie, "Toxins in the Collection: Museum Awareness and Protection" (2018). *Museum Studies Theses*. 16.
http://digitalcommons.buffalostate.edu/museumstudies_theses/16

Follow this and additional works at: http://digitalcommons.buffalostate.edu/museumstudies_theses



Part of the [Art and Materials Conservation Commons](#), [Fiber, Textile, and Weaving Arts Commons](#), and the [History Commons](#)

Toxins in the Collection: Museum Awareness and Protection.

An Abstract of a Thesis in Museum Studies

By

Nellie Slocum

Submitted in Partial Fulfillment of the Requirements for the Degree of:

Master of Arts

August 2018

State University of New York

Buffalo State College

Department of History and Social Studies Education

Thesis Abstract

The purpose of this thesis is to discuss museum policies regarding toxic materials used in the creation of an object or added to it as a preservation or pesticide technique. After surveying different museums, it has been found that many museums are unaware of what parts of their collections contain toxic materials. Because of this unfamiliarity with the danger these materials might pose, many museums do not have policies in place regarding them. Toxins in collection items may pose a threat to museum staff who are working with them on a day to day basis. Toxic materials are prevalent in any number of collections: this thesis focuses on three areas where toxic materials play a major part in the creation or their prolonging their life in museums. Lack of documentation of toxic materials in museum collection records can lead to mishandling of objects containing toxic materials and the potential for contamination by museum staff. This thesis argues that museums need to create safety plans that identify the toxic materials found in their collections, and develop training protocols to educate and protect staff members handling these objects, including providing protective equipment that will allow staff members to handle toxins without fear of contamination.

SUNY Buffalo State College
Department of History and Social Studies Education

Toxins in the Collection: Museum Awareness and Protection

A Thesis in
Museum Studies

By

Nellie Slocum

Submitted in Partial Fulfillment
Of the Requirements for the Degree of

Master of Arts
August 2018

Approved by:

Noelle Wiedemer
Lecturer
Thesis Advisor

Andrew Nicholls, Ph.D.
Professor and Chair
History & Social Studies Chair

Kevin J. Miller, Ed. D.
Dean of the Graduate School

Table of Contents

I.	Introduction	4
II.	Literature Review	6
III.	Toxins	12
	Arsenic	14
	Lead	19
	Copper	22
	Mercury	25
IV.	Toxins in the Collection	30
	Pigments	30
	Fashion	44
	Preservation and Pesticides	50
V.	Steps Toward a Safer Museum Environment	56
	OSHA	65
	CPSC	69
VI.	Conclusion	74
VII.	Works Cited	76

Chapter I

Introduction

Throughout history, toxins have been used in the creation of items of everyday use. From paintings and fashion to toys, medicine, and food. Some scientists have even used toxic materials in the preservation of natural history items like taxidermy. Some of these additional ingredients are often heavy metal in origin and are used to provide an extra brilliance to a color, keep away pests, or is that special ingredient that is able to help preserve an objects lifespan. The long term health effects of exposure to certain materials were virtually hidden or unacknowledged until many years down the road. Adverse health effects were generally acknowledged but were commonly attributed to another illness or were deemed to be insignificant (Finlay, 26-392). This means that these collection pieces, like paintings, historic fashion pieces, and items of natural history, made with these toxic materials, are sitting in museums across the world creating potentially dangerous environments for museum employees working with them on a day to day basis.

Do museums have a process, or guidelines regarding which items in their collection could be hazardous? Are they aware of which artworks, historic artifacts, or natural history collections contain toxic pigments? Starting with one category, like paintings, and identifying toxic pigments can be the first step in creating a safety plan and subsequent training needed to inform and protect museum staff employees. Resources like the Occupational Health and Safety Act (OSHA), the Consumer Product Safety Commission (CPSC), and industrial hygienists are available for further education, training, and evaluation.

The purpose of this paper is to explore what hazards are found in certain areas of museum collections, their characteristics, and discuss what policies museums have in place regarding them. This paper then seeks to identify what policies museums should have in place regarding toxic materials. Museums need to start identifying potentially toxic hazards in their collections and then create a plan of action, including staff training that works to protect individuals working with and handling these artifacts.

Chapter II

Literature Review

History has shown us that toxins have been used for everyday objects and tasks for thousands of years. It is only within the last 30 years or so that there has been an increased awareness of toxins, and not just in art materials. There are various databases compiled of toxins that become invaluable resources for people trying to further understand toxins. *PubChem* is one such resource. It is compiled by the National Center for Biotechnology Information. Each entry begins with identification of the toxin. From there, this comprehensive database covers methods of manufacturing, toxicity, first aid measures, OSHA standards, safe use, and disposal. The National Center for Biotechnology Information is an excellent resource for museums taking the first step toward identifying what hazards can be found in their collections and how to safely work with them.

Small doses of toxic pigments accumulate over time and create detrimental long term health effects. Reed Kay explains in *Toxicity of Pigments* that many artists, throughout the years, would work with these pigments breathing them in and carrying them on their clothes which would eventually brush off into their food to be digested later. There are many factors relating to a person that effects how much damage toxic pigments will wreak on one's body. Kay discusses three ways humans are exposed to toxic pigments; absorption, ingestion, and inhalation.

Though arsenic, mercury, lead, and cooper are widely used in the creation of pigments, they are not the only toxic substances used. *Painting & Drawing Pigments* by the College of Saint Benedict and Saint John's University is a list of all the pigments that have been in use throughout the years. The list contains the pigment's name, any nicknames it may have, a

description, whether they are hazardous based on different forms of exposure, and finally how the pigment might react to you. If a museum decides to take on the task of identifying what pigments might be in their painting collection this resource would be able to help further identify what risk a toxic pigment could present. Not all pigments in paintings are toxic so being able to weed out this information is crucial. Even if a museum does not go through their collection, this list should be kept on file. It is important to note that many of these toxins are heavy metals and were used in earlier paintings. Many contemporary artist's works can be hazardous because of the materials they use, like bodily fluids, fiberglass, and formaldehyde, but they will not be listed on *Painting & Drawing Pigments*. Those types of materials, though hazardous, are not discussed further in this work.

Michael Douma, curator of *Pigments through the Ages*, an online interactive museum, is an invaluable resource when trying to understand color and more specifically, pigments. Each article, whether it is on the history of color or each subsequent pigment, begins by outlining characteristics of the pigment, including historical development and identification. Since many pigments are not inherently toxic, Douma is able to separate them based on toxicity. *Pigments through the Ages* is able to convey how each pigment influenced history, its role in the pigment industry, and its toxicity. Museums are able to take the information collected by Douma and, with access to a department where paintings can be tested, identify which pigments were used in the creation of it. However, Douma's work isn't helpful when working with more contemporary paintings because his information is focused on earlier works of art.

Historical fashion of the 18th, 19th, and early 20th century is often labeled as deadly. Not only due to the flammable and constricting materials used to create these pieces, but also in the toxins used in their manufacture. Allison Matthews David goes over the numerous examples of

deadly fashion in *Fashion Victims: The Dangers of Dress Past and Present*, but what stands out is her work on mercuric hats and the green pigments used in headdresses and green dresses. Examples of people effected, like Matilda Scheurer, an artificial flower maker in London during the 1860s, and various hat-makers help express the dangerous environments that people were working and living in. Showing the history of why these toxins were used in the fashion industry and then the results of it helps give a background into why these pieces, now in museum collections, might be dangerous for people working with them today. David does an excellent job of incorporating modern examples, like mercuric hats in the Victoria and Albert Museum in London, and how these museums worked to protect their staff members working with the items, through bagging and identification tags labeling dangerous items.

Historical Survey of the Sources of Contamination of Ethnographic Materials in Museum Collections by Catherine Hawks examines the history of toxins being used in museum collections, mainly natural history, anthropological, and ethnographic. Explorers of the 19th century began using chemical pesticides as a preservative for their natural history collections as a way to ensure their survival during the long exploration and the journey to a museum. Harsh chemicals were needed to ensure the collections survival because natural methods were ineffective. Hawks is one of the few authors on the subject of toxins in museum collections that discusses the prevalence of toxins and how that can effect anyone handling them. She created timeline of pesticide use and the reasoning behind it to further support her claims. Hawks then relates it to present day practices and offers ways to help museums better understand what treatments have been done on collection items in the past. Knowing what has been used on collection items can help museums move forward protecting the object as well as museum staff members.

In *Arsenic & Old Lace: Controlling Hazardous Collection Materials* authors Kerith Koss Schrager, Anne Kingery-Schwartz, and Kathryn Makos create a foundation for museums to begin identifying hazards found in collections. They begin their work by distinguishing between inherent and acquired hazards in collections. It is important to make and understand this distinction because this information will influence how the objects are then handled and guide future preservation techniques. Then they present ideas on risk assessment and safety plans, both of which are very important for museums to go over. The information provided is useful in supporting the idea that many museums are unaware of some of the hazards lying in their collection. The authors help lay the groundwork on how to begin creating a safety plan through exposure assessments, identification, and communication. Safety plans are important in museums because they outline any disaster planning, occupation health and safety, and risk management. Museums are then able to implement techniques that assist staff members in dealing with hazards.

Occupational Safety and Health Act (OSHA) of 1970 written by the Society for Human Resource Management contributes a concise summary of what the act entails and highlights certain aspects within the act that have created frequently asked questions. The Occupational Safety and Health Act ensures that employees as well as employers throughout the United States in addition to the United States' territories are provided a state approved job safety and health plan. Employers, covered by OSHA, have over 10 people working under them must have three types of records, indicated through OSHA, detailing job related injuries and illnesses. Exempt employers can include organizations with fewer than 10 employees in low hazard industries. It would be a natural state of thought for museums to fall under the exempt status because the majority of museums have under 10 paid employees ("Occupational Safety and Health Act

(OSHA) of 1970," 2008). Not having safety standards in place could cause more harm than good when a volunteer staff member isn't properly trained to handle moving a potentially hazardous top hat felted in a mercury solution. However, having a safety plan in place that includes some standards set by OSHA could benefit a museum that may not have to uphold the more strict guidelines set by OSHA but also has a set of standards to follow in order to protect themselves.

Health & Safety Labeling, and Other Chemical Hazard Management Issues in the Arts as found on the Hamilton College's website provides a set of information regarding labeling hazardous materials in the arts, compiled by Hamilton College. They discuss some of the laws enacted regarding health and safety labeling, starting with the Labeling of Hazardous Art Materials Act of 1990 through the California Proposition 65 and the OSHA communication standard. This information demonstrates what laws are already in place regarding hazardous art materials. Proper labeling on art materials is very important for both artists and museums. For the artist, they can now know what materials are used to make up the pigment they are using and then proceed safely. Some museums like to allow students and visiting artists to paint in their gallery spaces, proper labeling on art materials allows museums to better control what paints are used in their spaces. These laws were only put in place during the last 30 years, so this supportive information helps show how long people may have interacted with these toxic pigments before truly knowing what they were working with and how to safely use them.

Many pigments in museum environments, especially in more modern times, are regulated and some procedures are in place to protect museum staff from exposure. However, the risk is still present through unstable environments and damage to the object that can cause health effects to anyone exposed to it. Current literature touches on toxicity in collections as well as safety plans or some sort of risk management in museums, however, none of them truly combine the

two concepts. This paper is to be a resource for anyone looking for more information regarding toxic materials in collections.

Chapter III

Toxins

One of the greatest misconceptions that people have when they are exposed to toxic materials in small quantities, is that they will be fine. However, these small doses of toxins can add up over time and can eventually have a large effect on a person's health. In history, there have been times when individuals have risen up and tried to take a stand on toxic materials in pigments and fashion, but it was not until later, that people really begin to discuss the dangerous effects toxins like arsenic, cadmium, chromium, lead, mercury, or manganese. Some of these pigments included cadmium reds and oranges, chrome oxide opaque, manganese blue and violet, vermilion, among many others. For historical fashion and preservation techniques, arsenic and mercury were the main offenders. In history, toxins could be found everywhere, in medicine, interior decoration, pest control, toys, and food. The environments where these toxins were being painted, buffed, or submerged, could get on clothing making it easy to travel from a studio or factory into the home (David, 4-119).

There are three main routes of exposure to toxic materials, absorption through the skin, inhalation, and ingestion. The rate of absorption to the emergence of symptoms depends on many factors like health, age, any other previous illnesses, and one's physical condition. For example, the amount of tobacco inhaled and the amount of alcohol consumed will play a contributing factor (Kay, 1-3). Absorption through the skin can happen through many different avenues. Toxic pigments can cause skin irritation or skin allergies upon exposure. Toxins can also get under the skin through cuts or scrapes. Open blisters or sores can even be gateways for absorption. Once these toxins get into the bloodstream, they can cause severe allergic reactions or dermatitis, an inflammation of the skin. When working with collections that contain toxins,

museum employees must make sure their working area is constantly kept clean. Staff need to keep any open wounds covered no matter how healed they look. It is also important to always wear proper protective equipment when working with toxic collections. Band aids, disposable gloves, and protective eyewear are easy, inexpensive ways to protect yourself while working with these hazardous materials. Museums located in warmer environments need extra precautions when dealing with humidity control because it can lead to more moisture in the air which can cause warping, cracking, corrosion, and mold growth (Kay, 1-3).

The problem with inhaling toxic materials, particularly pigments, does not lie in any pastes, oils, or acrylics produced, it is when artists try to make their own pigments and mix together the dry pigment powders with adhesives or oils. Any drastic movement or breeze can cause the dry pigment powder to dust up and get into your lungs. Unfortunately, there are many art forms that require a dry pigment powder to be used. These art forms include frescos and encaustic techniques. That means that artists need to be aware that their work area is always clean and windows are shut tight. Even a slight breeze from an open window can cause the toxic pigment dust to billow about the room waiting to be inhaled (Kay, 1-3). Headdresses of Victorian England were often powdered with green arsenic. Working in an environment like this would involve breathing in the dry powders with little to no ventilation. Headdresses in museums today can still have some powdered green arsenic that can be blown into someone's face if hit with a breeze (David, 70-99).

Anyone working with collections that contain toxic materials are encouraged to always wear protective equipment. Respirator masks are recommended for anyone grinding their own pigments or working with spray paint. Respirators should be approved by the U.S. Bureau of Mines or the National Institute of Health and Safety. Many toxic pigments containing zinc

metals and lead metals become gaseous at high temperatures making it paramount for the area where artists work to have proper ventilation. In a museum setting, anything painted or submerged in a toxic solution must have proper ventilation and humidity control so not to off-gas if exposed to hotter temperatures or a moister environment. This protects the employees working with the collection as well as the visitor (Kay, 1-3).

Ingestion of toxic materials is probably one of the easiest ways to bring hazardous materials into the body. Working with dry pigments or natural history collections can get on fingers, utensils, and clothes which can then flake off into the mouth or onto food. It is very important for museum workers to keep areas where food or drink is ingested separate from where the collection items are being handled. It is also better to change clothes and even shower after working with these materials, all of this in an effort to eliminate the spread of these hazardous materials outside of the museum storage. Smoking should never occur in an area where hazardous materials are being worked because dry pigments can get on fingers which are then placed in the mouth. To avoid ingesting any toxins, it is important to make sure all work areas are scrubbed clean. Museums need to make sure collection items with the potential for flaking are not placed or stored near major air flow areas. Even a slight breeze can cause debris from the item to fly into the air which is then breathed into the lungs (Kay, 1-3).

Arsenic

Arsenic is quite popular when it comes to pigments and can be found in Scheele's green, Cobalt violet, and King's yellow, among others. Arsenic is a solid that is naturally occurring in nature, the 20th most abundant element. 3.4 parts per million of the Earth's crust is comprised of this naturally occurring arsenic. It is often metallic in color, ranging from silver to gray. It is a free element with an atomic symbol of As and is the third element in the VA (nitrogen) portion

of the periodic table. Combinations of arsenic can be classified as organic or inorganic. The difference between the two lies in the amount of carbon it contains. Inorganic compounds do not have any carbon (Lee et al., 45-53).

Throughout time there have been various records detailing different forms of arsenic. Reports stating authentic details of the free element begin with Aristotle (384-322 B.C.E) in the fourth century B.C.E. In his writings, he makes mention of a substance referred to as *sandarache*. It is now known that what Aristotle was referring to was the mineral *realgar*, which is a sulfide of arsenic. Pliny the Elder (23-79 C.E.), along with Pedanius Dioscorides (N/A-90 C.E.), recorded findings regarding something they called *auripigmentum*, now known to be arsenic trisulfide. During the 13th century, Albertus Magnus (1200-1280) was credited for the discovery of arsenic during experiments where *arsenicum* was heated with soap. It is still unknown whether Magnus can truly be credited for the discovery or whether he was observing another compound of arsenic. The true credit goes to Johann Schroeder (1600-1664), a German pharmacist, who in 1649 heated the oxide with charcoal, observing the free element. Schroeder was later followed by Nicolas Lemery (1645-1715), a French Physician, who was also able to create the free element through a mixture of soap, potash, and the oxide, heating it all together (Sanderson, 2014).

In 1867, chemists soon discovered the destructive power arsenic could wield when put into a paint pigment and used as a pesticide. This arsenic paint pigment pesticide was poisonous to insects and mold but the paint pigment could also be used as a house paint. Scientists felt that they had learned how to protect the populace from the effects of arsenic when used as a pesticide. This new form of pesticide was popular because arsenic was cheap to buy and as a paint pigment, it had a long life as well as the strength of other metallic elements. However, this

arsenic was taken from the waste products of mining and other industrial production. Around 1870, when big companies like Sherwin-Williams gained wind of this new pesticide, they advertised heavily in newspapers and magazines like “Country Gentleman” stating that a farmer’s insect killing ability was greatly increased when using this arsenic paint pigment as a pesticide. The most effective arsenic paint pigments were Paris green, Scheele’s green, and London purple. In the 1890’s, the liquid form of London purple was the pesticide of choice and then going into the late 19th, early 20th century it changed to the powder forms of Paris green and Scheele’s green. This switch from London purple to Paris green and Scheele’s green was in part due to the fact that the London purple pigment was killing off more plants than bugs. Throughout the 1800’s and even until the 1930’s, arsenic continued to be a staple in most manufacturing. Everything that was produced seemed to contain arsenic; food, clothing, paint, and even medicine (Allen, 75-80). Many wallpapers found in the home often featured arsenic ridden pigments. Arsenic from the wall paper could be spread throughout the home when the wall paper reacted with the wallpaper glue. In moister climates, the wall paper would secrete hydrogen cyanide into the home. Testing for arsenic was virtually impossible until the invention of the Marsh test in 1836, developed by James Marsh (1749-1846), and Reinsch test in 1841, by Hugo Reinsch (N/A) (David, 70-99).

Metallic arsenic can be manufactured through two different methods. First, sulfide can be heated to create the oxide and then reduced with carbon. Second, arsenic can be formed through the heating of arsenopyrite through the absence of air (National Center for Biotechnology Information, “Arsenic,” section 10.2, 2005). Both ways allow the arsenopyrite and any other arsenic impurities to unite with oxygen when heated. This forms white arsenic, which is later condensed into brick chambers and purified. The record for the world’s most consumption of

arsenic would be granted to Sweden. They use arsenic in their metallurgical processes because it has many metalloid characteristics (Sanderson, 2014). The common commercial use of arsenic, is in the manufacture of batteries and various metal products. Arsenic is found in many more products than that, including many different pigments, foods, dyes, and pesticides (National Center for Biotechnology Information, “Arsenic,” section 10.1.2, 2005). One percent of arsenic compounds are used in the creation of lead shot. This is because arsenic is able to round out the molten drops and bearing alloys of the lead. Arsenic is also used in the pyrotechnics industry for use in bronzing, giving objects the appearance of a bronze color as well as other semiconductor applications. Small doses of concentrated arsenic help improve the resistance to corrosion in copper and brass. Arsenious oxide can be found in pesticides, as a decolorizer during the creation of glass, and it even functions as a preservative for hides (Sanderson, 2014).

Today, many of the compounds in common items of daily consumption have been replaced with non-toxic versions. For example, in pigments, many of the toxic ingredients have been replaced with non-toxic ones, like Smalt being replaced by Prussian blue in 1828 (Douma, “Intro to the Blues,” 2008). This has come with various results. Some people are upset because the new product pales in comparison to the old but some are relieved not to have to worry about what they are using in their paints and the accompanying health effects.

The many different forms of arsenic range in toxicity and can be encountered through water, land, air, food, and skin absorption. The arsenic compounds found in various items are then ranked based on their toxicity and solubility. Many inorganic forms of arsenic, like arsine gas, have higher toxicities than organic arsenic compounds. These variations can range from extremely poisonous to fairly inert. The free element arsenic is stable when exposed to air but when humidity becomes involved, the element becomes coated with a black oxide. It is

unaffected by water, but when combined with halogens, arsenic will begin to form arsenides (National Center for Biotechnology Information, “Arsenic,” section 13, 2005).

Most exposure to arsenic and its compounds occur in an occupational setting. This exposure can be through pesticides, dry pigment powder, foods, or contaminated wood. Entry into the body is typically through inhalation or ingestion. The other route to arsenic poisoning is the environment. This comes in the form of contaminated soil or water, mining, smelting, and burning of fossil fuels. Arsenic has been confirmed as a human carcinogen through the American Conference of Governmental Industrial Hygienists (ACGIH). Many arsenic compounds tend to be skin irritants, but the main cause of arsenic poisoning comes from ingestion. The human body can withstand 0.5 milligrams per cubic meter of concentrated arsenic dust during an eight-hour period (Sanderson, 2014).

There are numerous health hazards that are associated with arsenic, including many types of cancers, anemia, neurological symptoms, and respiratory changes. Moist lips, eyelids, pharynx, and other wet surfaces are the most likely to first pick up the arsenic dust. Dust can also enter food or drink through open windows. Some acute (short term) symptoms of ingestion can consist of gastrointestinal irritation, hemorrhages, vomiting, abdominal pain, and watery diarrhea. Many of these signs and symptoms of arsenic poisoning are like to that of cholera and are often mistaken for it. Outward signs of arsenic poisoning can be seen on the nails in the form of Mee’s lines. Mee’s lines are horizontal lines across the nail that is the result of injury to the nail bed. These lines can be seen on the nail for weeks to months after the initial arsenic poisoning. The risk for lung cancer is greatly increased after the inhalation of an inorganic arsenic compound. The risk increases even further with higher concentrations. Other chronic (long term) cancers caused by arsenic poisoning are skin, bladder, and liver. Some neurological

effects have been linked with arsenic poisoning that could progress to a sensorimotor distal axonopathy, a disease that effects some peripheral nerves. Recovery from this sort of damage does not come easy and it may take many years, if recovery is possible at all. During short exposures to the toxin, some nasal obstruction could occur, creating a swollen larynx and making it hard to breathe (Lee et al., 45-53).

There are quick first aid measures to combat arsenic exposure to the eyes, skin, ingestion, or inhalation. These first aid measures are for initial exposure and should all be followed up by a visit to the hospital or a primary care doctor. If arsenic comes into contact with the eyes, both the upper and lower lids should be immediately washed with generous amounts of water. When working with arsenic, never wear contact lenses. If arsenic comes in contact with the skin, make sure to immediately wash the skin with soap and water. It is always better to quickly change out of the clothes that were exposed and get on new ones. If acute symptoms occur due to inhalation of the toxin, it is important to get the exposed person into fresh air, breathing deeply for several minutes. Finally, if the toxin is swallowed, seek medical attention immediately. Even if there is a slight chance you might have swallowed it, seek medical attention before any major symptoms occur. Some symptoms of arsenic poisoning can occur within 30-60 minutes, but some are delayed by several hours. That is why it is important to always exercise caution when in contact with the toxin and get regular checkups at a primary physician (National Center for Biotechnology Information, "Arsenic," section 12.1.2-12.5, 2005).

Lead

Lead is a well-known toxin, seen in stationary, pipes, paint, and cosmetics. It is a naturally occurring metallic element of soft metal, silver or white in color. Found in the Earth's crust, lead is close in abundance to that of tin. This metal is quite dense and elastic, making it a

poor conductor for electricity. Located in group 14 of the periodic table, its symbol is Pb. The symbol for lead is actually an abbreviation of the Latin term *plumbum*, which means lead (“Lead,” 2013).

Lead has been used in homes as far back as the Babylonian Empire, where it was used in the creation of metal plates on which inscriptions would be recorded. Around 200 B.C.E. the white lead pigment was introduced. This pigment would stand the test of time, lasting until the early 20th century. Lead was also quite popular during the Roman Era, where it could be found in water pipes, coins, and utensils. It was during the time of Augustus Caesar (63 BC- 14 AD) that the toxicity of lead first became recognized. Today, lead deposits can be found across the world, primarily in North America, Europe, Africa, and South America. In the United States, lead deposits are located in the Mississippi Valley and in the Western half of the country (“Lead,” 2013).

Starting in the early 21st century, China, the United States, Mexico, and India became the world’s top producers of lead concentrate. The majority of refined lead is produced from recycled scrap. During manufacturing, lead is taken from the ore through extreme heat and then is smelted down. After further refining, impurities are completely taken away. Due to lead’s chemical resistance, it is often used in roofing and electric cable coverings (“Lead,” 2013). Lead is easily combined with other materials to create many different compounds. These compounds have led to significant advancements to our industrial processes and in our visual and creative arts. In our visual and creative arts, lead can be found in the chemical used to develop photographs. It can also found in ceramics, pigments, dyes, and cosmetics (Williams, 2015). From the Roman Era through today, lead has been used for the linings of water pipes carrying water or corrosive materials. Lead can also be found in the manufacture of storage batteries and

ammunition. Some lead sheets are used in industrial machinery to cut down on the noise and vibration coming from the machines. When one goes to a doctor or dentist's office to get an x-ray, a heavy lead vest over you the patient for protection. Lead is able to absorb the electromagnetic radiation of short wavelengths coming from the x-ray machine ("Lead," 2013).

Lead and its compounds are toxic. Very short term exposure to lead isn't harmful but exposure to lead can build up and is retained by the body for long periods of time. As lead's solubility increases, so does its toxicity level. Exposure to lead can happen though ingestion, inhalation, and absorption through the skin or eyes ("Lead," 2013). Some exposure can come from everyday routines that are not thought about. One can breathe in the exhaust from a car or even planting in a garden. Lead still exists in the soil from being deposited there decades ago. Older homes can still have lead paint on their walls as do older bridges. In agriculture, some practices still include the use of lead containing pesticides for their crops (Williams, 2015).

Cancers developed by interactions with lead have not been confirmed in humans but tests involving animals confirm that they developed renal tumors and cancer from exposure. Lead exposure in children can lead to different developmental and cognitive deficits. Symptoms of lead poisoning include; vomiting, abdominal pain and cramps, constipation, and headaches or dizziness ("Lead," 2013). Lead poisoning can also lead to break downs in the immune and cardiovascular systems, causing damage to the brain and kidneys. Reproductive deficits have been seen in cases of prenatal exposures to high amounts of lead. Lead poisoning can target different organs of the body, like the heart and blood vessels, digestive organs, muscles, and can affect the development of organs throughout growth (National Center for Biotechnology Information, "Lead," section 12.7, 2016). Distancing oneself from the toxin and elimination of the toxin entirely should be enough for one to be cured of lead poisoning, so long as there isn't a

large buildup of the toxin in the system (“Lead,” 2013). Throughout the 20th and 21st centuries, there has been a large movement to actively eliminate and ban lead from everyday products, like pesticides, pigments, and office supplies.

Some first aid measures to think of if lead comes in contact with the eyes are as follows. Make sure the person is not wearing any contact lenses. If they are, promptly remove them. Proceed to flush the eye with a saline solution or water for half an hour. Contact a poison control center for further instruction. If lead comes in contact with skin or clothing, remove all affected clothing and wash all areas of the skin that were in contact with lead thoroughly with soap and water. Should any further symptoms or redness develop, contact a doctor or a poison control center (National Center for Biotechnology Information, “Lead,” section 12.3, 2016).

Upon inhalation of lead, immediately go outside into the fresh air, taking deep and controlled breaths. A visit to the hospital or an urgent care is also highly recommended even if no other symptoms occur. If a lead metal is ingested, proceed immediately to a hospital or poison control center. It is further recommended to locate some activated charcoal, egg whites, or milk in the case that the doctor asks them to be administered to the effected person in an effort to help combat the poison (National Center for Biotechnology Information, “Lead,” section 12.3, 2016). These first aid measures are for initial exposure and should all be followed up by a visit to the hospital or a primary care doctor.

Copper

Copper is another naturally occurring metal, reddish-gold in color that can be found in rocks, soil, water, and air. Copper is also found in plants, animals, and humans. Though copper does occur naturally, it is most often found in minerals, like chalcopyrite and bornite. Copper can

be removed from these minerals through smelting or electrolysis. Copper is unusual compared to the other toxins mentioned in that it is necessary for us, as humans, to live. We need to absorb copper through breathing or from eating and drinking to survive. Copper, in our bodies, is used to boost our immune system and helps create red blood cells and collagen (National Center for Biotechnology Information, “Copper,” section 13, 2017). Humans need 1.2 milligrams of copper a day to support our systems. Any more than that and it quickly becomes toxic for us. There are diseases associated with our body’s use of copper, like Wilson’s disease and Menke’s disease. Both inhibit copper’s ability to function properly inside our bodies. Both are also genetic. Copper’s atomic symbol is Cu. Chronic exposure to copper can have lasting effects on the reproductive systems as well as developmental and nervous systems. Copper poisoning targets the blood and bone marrow in addition to both the central nervous system and the peripheral nervous system. Exposure can cause anemia, encephalopathy and nerve damage. Reproductive damage has also been linked to chronic copper exposure (“Copper...,” 2017).

Historical records indicate that copper was the first metal to be worked on by humans. Humans soon discovered that copper could be shaped and hardened with a bit of tin, creating bronze. This discovery of bronze led the world into what we call ‘The Bronze Age.’ During the Bronze Age, the copper and tin alloy would be utilized in the creation of cooking utensils, coins, and tools. In certain regions of Iraq, archaeologists have uncovered copper beads dating back over ten thousand years. These beads are believed to have been made with native copper, instead of a copper compound (“Copper...,” 2017). The United States’ pennies created before 1982 were made from copper, in addition to silver and gold. After 1982, the pennies are only coated with copper. Copper compounds can be found in agriculture to combat plant diseases like mildew. Copper is also used as a water treatment to preserve wood, leather, and textiles. Copper

compounds are used frequently in pigments and paints throughout history. Finally, one of the main materials used in the creation of the Statue of Liberty, was copper (The National Center for Biotechnology Information, “Copper,” section 13.1.5, 2017).

Copper has a wide range of uses beyond that of sustaining our body. Copper can be found in industrial settings as plating agents as well as surface treating agents, or as fillers. Copper is sought after in industrial settings because it is able to conduct both heat and electricity very well, making it a suitable candidate for forming into wires. In our general consumer uses, copper is used in batteries, pigments, electrical products, food packaging, and construction materials. In agriculture, copper sulfate is used as a pesticide and as an algaecide in water purification. It is not very difficult to extract copper from its ores, but copper deposits are scarce. One of the oldest copper mines is located in Falun, Sweden and dates back to the 1200’s. Other copper rich countries are Chile, Peru, and China. Around 80% of the primary copper used comes from low-grade sulfide ores. The copper is extracted through pyrometallurgical methods, heating the metal to extreme temperatures to extract and purify the metal (“Copper...,” 2017).

Even though small amounts of copper are good for the body, any more than that becomes toxic. Short time exposure may not have a small, if any, effect on the body but over time repeated exposure could build up in the body and cause problems. If the copper exposure becomes too much, there are quick first aid measures that can help save a life. These first aid measures are for initial exposure. Copper can be absorbed into the body through the eyes, skin, inhaled, and ingested. If copper comes into contact with someone’s eyes, immediately wash out the infected eye with water or a saline solution for half an hour or more, making sure to switch between the upper and lower lids, ensuring the entire eye is cleansed. If copper comes in contact with the skin, wash the contaminated skin multiple times. Clothing that comes into contact with

copper should be removed and washed immediately. Finally, if the copper element is swallowed, seek medical assistance right away and contact a poison control center (National Center for Biotechnology, “Copper,” section 13.3, 2017).

Mercury

Mercury is a common toxic ingredient most often found in collections. Mercury is well-known ingredient in thermometers, fluorescent light bulbs, and batteries. Mercury is a silver metallic element, with an atomic symbol of Hg on the periodic table. The two most interesting things about mercury, is that all forms of mercury are toxic, and it is only within the last 30 years that there have been major strides to remove mercury from everyday products. Mercury is actually second, only to lead, as a cause of heavy metal poisonings. Mercury exists in three forms, elemental mercury, inorganic mercury compounds, and organic mercury compounds. Inorganic mercury compounds often come in the form of mercuric chloride and organic compounds are typically methyl mercury. (National Center for Biotechnology Information, “Mercury,” section 10.6 2017).

Mercury’s claim to fame, arguably, could be its contribution to the pigment vermilion, or mercury sulfide. Mercury is obtained through heating the mineral cinnabar and then condensing the vapor produced. Vermilion has been in use as far back as the Paleolithic Era, with evidence gracing the walls of caves in Spain and France. Roman gladiators would have raw vermilion painted on their bodies before fights. On festival days, the statues of gods and emperors would be adorned in the pigment. European monks during the middle ages used vermilion for their manuscripts, adding ear wax to it in order to prevent pigment foaming (Varichon, 11-258). The mercury provided for Europe was mined from the Almaden deposit located about 200 miles south of Madrid, Spain. Even today, this mine can boast about being the most productive

mercury mine in history. Workers would mine the mercury 700 feet underground for six eight-hour shifts per month equipped with full masks and ventilation (Finlay, 26-392).

Cinnabar, a form of mercury (II) sulfide, is quite well known, in its liquid form, for being able to dissolve gold. Ancient people would use cinnabar to extract gold from the sediment in rivers. During the 1848 California Gold Rush, miners used mercury taken from the New Almaden Mines in California to help them find gold (“Mercury”, 2017). In 1990, the last United States mine ceased production and now all mercury comes from secondary sources, like empty batteries, dental amalgams, laboratory wastes, and fluorescent lights (The National Center for Biotechnology Information, “Mercury,” section 10.6, 2017).

Mercury is everywhere in our environment, even in our food. We take in less than 0.01 milligrams each day. Any more than that and we would suffer from mercury poisoning. Seafood with high mercury levels, like tuna and swordfish, are good examples of mercury intake. It is important to make sure that we are not eating a lot of fish within a certain time frame. Too much seafood can cause mercury poisoning, resulting in gastrointestinal issues and red flakes appearing in our hair. Mercury used to be a major component in the manufacture of sodium hydroxide and chlorine through the electrolysis of brine but because of the recent push to cease the use of mercury in products, all plants using this method will stop production by 2020. Elemental mercury is also used in the production of batteries, fluorescent light bulbs, thermometers, and barometers. Plants utilizing mercury for these products will also stop production soon. Mercury salts are used therapeutically as antisyphilitics, disinfectants, and astringents. Safer and more effective therapies are being introduced as alternatives to replace the toxic mercury. Inorganic mercury, in the past, has been used in the production of laxatives, cosmetics, soaps, pigments, and paints. The EPA (The United States Environmental Protection

Agency) banned the use of mercury in interior paints in 1990 and the use of mercury in exterior paints in 1991 (The National Center for Biotechnology Information, “Mercury,” section 10.1, 2017).

Unlike arsenic, lead, and copper, mercury does not exhibit any symptoms upon contact. As the mercury builds up in your system, nausea, muscular tremors, and diarrhea may occur. Kidney and cardiovascular problems may also appear. Each form of mercury compounds, elemental, inorganic, organic, display different acute and chronic effects on the body. Acute exposure to elemental mercury can result in tremors, mood changes, and damage to motor nerve function. All of these symptoms are related to the central nervous system. Chronic effects also include central nerve system damage but symptoms of irritability and increased excitability as well. Acute exposure to inorganic mercury can cause nausea and abdominal cramping. Major kidney damage can occur through chronic exposure to inorganic mercury. Blindness, deafness, and other central nervous system symptoms may occur through acute exposure to organic mercury, or methyl mercury. Through chronic exposure, paresthesia, which is the sensation that your skin has many tiny pricks on it, speech difficulties, and vision problems occur. If mercury poisoning happens while you are pregnant, the child may develop developmental disabilities, blindness, or cerebral palsy. Up to this point, there are been no conclusive studies linking mercury poisoning and the emergence of cancer (National Center for Biotechnology Information, “Mercury,” section 13.1.8-13.1.9, 2017).

Like most toxins, mercury can enter the body through the eyes, skin, mouth, or airways. These first aid measures should all be followed up by a visit to the hospital or a primary care doctor. Some quick first aid measures when mercury comes into contact with your eyes, immediately wash out the infected eye with water or a saline solution for half an hour or more,

ensuring that the entire eye is cleansed. Contact lenses should never be worn when working with mercury. If mercury happens to come in contact with skin or clothing, remove all affected clothing and wash all areas of the skin that were in contact thoroughly. Should any further symptoms or redness develop, contact your primary doctor or a poison control center. Upon inhalation of mercury, immediately go outside into the fresh air, taking deep breaths and controlling your breathing. If mercury is swallowed, seek medical attention immediately. Even if there is a slight chance you might have swallowed it, seek medical attention before any major symptoms occur (National Center for Biotechnology Information, "Mercury," section 12.3, 2017).

Sometimes it is very alarming to really think about how many items we use every day are made with toxic materials. Though many of these items pose no threat to our health just by handling them, some can cause major problems for us just through a tiny slipup. Mercury thermometers used to be made of glass. Sometimes it is quite easy to knock something over on accident and if you knocked over one of those thermometers, you might be in some trouble. Knowing how someone is affected by these different toxins is the first step in overcoming the dangers. Basic first aid procedures are especially important when first exposed to these toxins. In addition, professional medical attention should then be sought out.

Arsenic, lead, copper, and mercury are present in an abundance of items that we use daily. When used in the creation or as a preservation technique on museum objects, these toxins can live on these pieces for years. Toxins can be absorbed, inhaled, and ingested easily when not using caution or when improper equipment is being utilized. As discussed, there are simple first aid measurements to take when exposed to toxins in collections but it is always important to

work in an environment that is safe and properly equipped so that the toxins do not build up in the system.

Chapter IV

Toxins in the Collection

Pigments

Color is a fascinating subject. Color is not physically there, but it is a function of our visual system. Objects around us do not actually contain color; they give off the appearance of color and our minds interpret what it is. Color is the product of frequencies and those frequencies determine a color as they travel to our eye based on how they are combined (Elert, 2017). This is called visible light, wavelengths that are visible to our human eye. Visible light is part of what is known as the electromagnetic radiation scale. The electromagnetic radiation scale includes visible light, but it also includes ultraviolet radiation, x-ray radiation, infrared radiation, and radio waves. Visible light is in between infrared and ultraviolet radiation on the scale (Lucas, 2015). When light is reflected off an object it travels to our eyes, specifically the back of our eye called the retina. In the retina, we have special receptor cells that sends a signal to the brain through our optic nerve that tells us what color it is. If the frequency given off is too low, it appears invisible to our eyes. As the frequency increases we start to see color. The first color our eye perceives is red, specifically a dull red. From there, with increased frequency, color travels through the rainbow spectrum of red, orange, yellow, green, blue, indigo, and violet (Elert, 2017). What we perceive as the color white is all of the colors being reflected to us all at once, just as the color black is all the colors being absorbed and none are reflected to us.

A pigment is a “colored substance which is insoluble in and physically and chemically unaffected by the medium in which it is dispersed” (Thomas, 8). Pigments are insoluble in both binders and solvents. Pigments are what makes up the color and durability of paints (Armitage,

1-15). They are classified by their origin or their composition. Pigments can be made through organic or inorganic means. Organic pigments are created through animal, vegetable, or synthetic materials. Inorganic pigments are created either by minerals or synthetically. There are three components to what makes up a pigment. There is the color of it, better known as the basing agent, the modifying color agent, and the base filler, also known as the diluent or carrier. The color basing agent is often iron oxide because its natural properties determine the color, and iron oxide can be found all over the world. Some modifying color agents include calcium, manganese, silica, limestone, and carbon. Many carbon based materials can darken the iron oxide color, whereas the manganese will change a brown color to black. Having a clay base to your pigment is the most helpful because the clay will lighten the iron oxide colors (Thomas, 7-24).

In more modern times, the chemical process of creating pigments has changed everything. We now use more synthesized pigments over natural ones. Industrial revolutions throughout the world have helped to develop different materials used in the manufacture of pigments. The manufacture of these pigments by commercial means have also led to the decrease in artists actually creating their own pigments. Earth colors are still in use today, also for purposes other than art. Their popularity has continued because they remain permanent throughout exposure to sunlight, humidity, and temperature changes. They are non-toxic and have little reaction to solvents which makes them popular choices for use in foods and cosmetics (Thomas, 7-24).

Synthetic iron ore pigments are produced through a chemical process. The materials used in this process come from the waste products of metallurgical industries. There are two different methods of manufacture of synthetic iron ore pigments. The first is through a thermal

decomposition, which is a two-step dry process that calcifies iron salts. The second is a solution method, a wet process, created in 1920 that consists of the controlled rusting of iron that produces various shades of yellow (Thomas, 7-24).

Lead white, or lead carbonate is said to be the greatest and the most dangerous of the white pigments. Rutherford Gettens (1900-1974), of the Fogg Museum, has been quoted saying that lead white is “the most important pigment in the history of Western painting” (Finlay, 120). Lead white also goes by the names flake white, foundation white, basic sulfate, and Cremnitz white (Environmental Health and Safety, 2017). During ancient times, lead white was produced through shavings of lead dumped in a bowl of vinegar. The acid formed on the metal instigates a chemical reaction that dispenses a white deposit of lead carbonate, hence the name lead white. It seems that knowledge of this deadly pigment was well known and written about through ancient Roman texts but no one seemed to care about the consequences. Pliny the Elder (23-79 A.D.) even included the lead white pigment in his work *Natural History*, stating that this pigment was toxic if ingested. However, Pliny does not get into further detail as to the effects of lead white when it is absorbed through the skin or through inhalation. In more modern times, the recipe for making lead white has been largely the same, except a new addition brought about by the Dutch during the 17th century. Artists would have two clay pots, one for lead and one for vinegar. Once these pots were lined up, fresh manure would be added to the pots thus providing the necessary carbon dioxide and heat needed for the compound to evaporate the acid and begin a chemical process changing the lead acetate to lead carbonate. The room where this process was conducted would be sealed for three months, allowing microscopic white crystals to form on the lead and produce the purest white formed in flakes (Finlay, 26-392).

Lead white can be traced back all the way to 400 B.C.E. when Pliny the Elder and Vitruvius (N/A-15 AD) detailed its manufacture formula (Douma, "Lead White," 2008). Throughout the years, lead white has been used across the world but the majority of its popularity being focused in Europe and Asia. In Iran and Smyrna (Turkey), lead white was used to paint their boats, and the Chinese would add lead white to their inks. Many of the rich, vibrant portraits found in Fayum, Egypt featured lead white to create vibrancy. The Middle Ages favored lead white in their manuscripts because of its tendency toward opacity and wide range of coverage, bearers could trace the most delicate designs with only one sweep of their brush. Renaissance artists would begin their works by covering their canvases with lead white in order to create a sense of light later on in their work and then adding it to other colors to build up layers (Varichon, 11-258). Evidence of lead white in paintings can be seen in highlights, the glimmer on silver jars, and the reflection on white teeth. Lead white dries the fastest of all the other whites which makes it a favorite to artists who need a faster drying time as well as artists working in the Alla Prima technique. The Alla Prima technique is a wet-on-wet technique used in oil painting where wet paint would be added to previous layers of wet paint. It was the only white pigment European easel painters would use until the 19th century. In more modern times, some companies still offer the lead white pigment but under the name cremnitz white. However, the original recipe for cremnitz white hasn't been used since 1938 (Douma, "Lead White," 2008).

In 1780, Frenchmen Bernard Courtois (1777-1838) and Louis-Bernard Guyton de Morveau (1737-1816) set out to try and discover a paint that was less toxic than lead white but still maintained its brilliance. Social activism was strong during this period and so these two men set out to advocate for the poor because they were the ones creating this toxic pigment and

therefore bore the brunt of the health effects associated. Courtois came from a scientific background as a demonstrator at the Academy of Dijon and Guyton de Morveau was a magistrate who would eventually rise to become one of France's greatest chemists. Over the next two years, the two men experimented and eventually discovered a pigment combination of barium and Sulphur, later named "*blanc fixe*" in 1924. This non-toxic pigment turned out to be relatively permanent but artists still did not approve of it as an oil paint and was deemed too transparent for their taste. Unfortunately, barium is quite rare, making the new non-toxic pigment lose popularity quickly, not surviving long on the market. The duo continued their experiments, now focusing on a zinc oxide combination once used by the Greeks as an antiseptic. Artists were quite pleased with this new revelation, praising its color and superb absorbency. However, this new pigment did not survive long either. Lead white cost less than two francs at the time and the new zinc white cost around four times that amount, making sure that no one was very interested in buying it. After these disasters, Courtois and Guyton de Morveau moved on to other things, Courtois went into the saltpeter production industry and Guyton de Morveau began experimenting with metals (Finlay, 26-392).

Since lead is quite dense it can be seen in x-radiographs. When looking at Titian's *The Death of Actaeon*, x-radiography can show us some pigmentation problems covering the mighty hunter. When Titian (1490-1576) was painting this masterpiece, he tried to pay close attention to the exact moment of Actaeon's transformation by painting swirls and then overpainting them in lead white. He did this over and over again until he was finally satisfied with the result (Finlay, 26-392). Finally, in the 20th century, lead white was banned from use because of its health risks and was replaced with zinc white (Varichon, 11-258). More specifically, in 1994, lead white was banned from the European Union and artists were told to use more titanium based white

pigments. The results of the new pigment were unsatisfactory, the white given off was not as vibrant or sharp. Many artists still miss the vibrancy, opacity, and coverage lead white allowed them. It leads to the question of, why would people use this deadly pigment for so long if the health risks were potentially so strong? One answer would be that, there really were not any alternatives available, especially in the field of watercolors until around the 1780's. Lead white was prevalent in oils for much longer, finally receiving an alternative during World War I when titanium paint was invented (Finlay, 26-392).

Since lead white is toxic, the utmost care should be taken when handling this deadly pigment. It contains basic lead carbonate, basic lead sulfate, and small trace amounts of zinc oxide, all of which are hazardous to your health. In its powder form, it is possible to inhale its dust which can be highly toxic to your health. When the pigment is combined into an oil paint, it is possible that lead white can be used without health risks, as long as safety precautions are in place. Which means it is very important to keep all work areas clean and clear of any solvent or mixing agent that could come in contact with the pigment. No food or drink should be kept near the work area because lead white is highly toxic if ingested. Soap, water, and good cleaning habits should be the most important aspects of a workplace. This includes proper ventilation systems put in place and adequate respiratory masks (Environmental Health and Safety, 2017).

Vermilion, or better known as cinnabar, Chinese vermilion, or English vermilion, was reserved for the elite. There were not abundant resources and it was not a universally used pigment, making it quite expensive. During the Byzantium era, only the imperial class were able to wear or use vermilion, all others would be put to death. Imperials would wear vermilion as well as use it in their imperial letters and edicts (Varichon, 11-258). Roman gladiators would have raw vermilion painted on their bodies before fights. On festival days, the statues of gods

and emperors would be adorned in the pigment. Many murals that grace Pompeii were made with a red ochre pigment, but the interior designs of the homes of the wealthy were adorned with vermilion. The vermilion used to paint all the statues and bodies of Rome's finest was mined from what was once the greatest mercury mine in the Classical world, located at Almaden. Today, this would be located about 200 miles south of Madrid, Spain. During the 16th century, prisoners could choose between the galley, a type of warship propelled by rowers, and working at Almaden. Even today, this mine can boast about being the most productive mercury mine (Finlay, 26-392). European monks during the Middle Ages used vermilion for their manuscripts, adding ear wax to it in order to prevent pigment foaming (Varichon, 11-258). Some artists of the time would use vermilion's raw state with Sulphur to create a purer version of the pigment. Vermilion has a tendency to resist blackening or fading as long as it is not exposed to bright or direct sunlight for too long (Finlay, 26-392). During the eighth century, vermilion began to be made artificially and was the primary color on many artist's palates until its synthetic equivalent, cadmium red was created (Douma, "Vermilion," 2008).

The name vermilion comes from the Latin word *vermiculus*, which means small worm and from the word *vermis*, which means worm. The chemical name for vermilion is mercuric sulfide, or HgS. The main deposits of vermilion can be found in Almaden, Spain, but there are other smaller deposits throughout Europe, China, Mexico, and California. To create the natural form of vermilion, the mineral is crushed and then purified in a succession of washing and heating. There are two main methods of production, the dry method and the wet method (Douma, "Vermilion," 2008). Recipes for both methods of production are frequented throughout medieval treatises. Treatise descriptions are largely obscure, incomplete, or try to use large quantities of sulfur. The dry method was created and used by ancient alchemists, whereas the wet method was

developed in Europe, mostly Germany and England. When vermilion is artificially made, the mercury in the pigment is combined with a molten sulfur, which creates a black amorphous HgS with a red crystalline structure. This manufactured vermilion differs from the natural pigment, in that it now has more uniformed particles. Vermilion can be identified under ultraviolet fluorescence as a dark blue color and under infrared false color as yellow. Vermilion is not nearly as toxic as far as some pigments go. When in its natural state it is even considered non-toxic, especially when combined with Sulfur. The mercury in vermilion is what makes this pigment toxic and great care should be taken when handling it in its dry powder or when it is dispersed in medium (Douma, “Vermilion,” 2008). Ingestion and inhalation of this pigment could create a buildup of hydrogen sulfide when it is combined with the acids in the stomach. Absorption through the skin is much less toxic but the dry pigment could cause some skin allergies and irritation (Environmental Health and Safety, 2017).

Naples yellow, also known as antimony yellow, is one of the oldest synthetically made pigments. Its strengths lie in its binding power, drying properties, and stability. However, this pigment is toxic. It contains lead antimonite, zinc and bismuth oxides (Environmental Health and Safety, 2017). Its structure is the same to that of the mineral bindheimite, which is a natural mineral not used for pigments. To create Naples yellow, artificially, requires the calcination of a lead compound, this could include an oxide or nitrate, to an antimony compound, like oxide or sulfide. The 19th century brought about a new recipe for the synthetic creation of Naples yellow. First, ceruse, sulphuret of antimony, calcined alum, and sal ammoniac must be ground down into a fine powder. That powder is then heated at a low temperature that increases in intensity. This oxidation process will take at least five hours, eventually producing Naples yellow. The color is finally washed and dried (Douma, “Naples Yellow,” 2017).

This toxic pigment's origins date back to ancient Egypt and Mesopotamia, when Naples yellow would tint the glazes used in glassmaking. Scientists have even found traces of Naples yellow in Babylonian bricks dating back to around 453 B.C.E. (Douma, "Naples Yellow," 2017). The Romans eventually replaced Naples yellow with a lead-tin pigment, but it made a comeback during the Renaissance times (Varichon, 11-258). During the rise of the watercolor era, this pigment was a staple on landscape artist's palettes because of its ability to blend in with the area surrounding it rather than standing out and detracting from the rest of the scene (Douma, "Naples Yellow," 2017). Naples yellow has been made artificially since the 15th century. During the 19th century, this pigment was largely used for interior design than art itself. Eventually, in modern times, the name Naples yellow often leads to associations of the color more than its chemical composition and toxicity (Varichon, 11-258).

Naples yellow's, or lead (II) antimonite, chemical structure is $\text{Pb}(\text{SbO}_3)_2$. It has a refractive index of 2.01-2.28. Through infrared false color imaging Naples yellow can be seen as white. Optical microscopy shows that the Naples yellow particles are homogenous but has no definite crystalline form, which is to be expected from a synthetic pigment. The Naples yellow pigment was a favorite among artists because in oil paintings, it is quite permanent. The downside to this pigment lies in the fact that when it is exposed to air containing hydrogen sulfide, it is likely to darken. In watercolors, this pigment swiftly darkens in color when in contact with Sulphur compounds (Douma, "Naples Yellow," 2017). Since Naples yellow contains lead it is toxic, however, it is unknown how toxic this pigment is when it is ingested. It is highly toxic when its dry powder inhaled and only moderately toxic when it comes in contact with the skin. It is important to always keep a work space clean when dealing with dry pigments, especially one like Naples yellow. Never eat or drink anywhere near where art is being made

because even a slight wind from an open window could cause the dry pigment to fall into food or drink. Symptoms of lead poisoning include nausea, abdominal pain, vomiting, and fatigue. If working with toxic dry pigments, it is always important to get regular checkups from a doctor (Environmental Health and Safety, 2017).

In the late 1700's, Swedish chemist Carl Wilhelm Scheele (1742-1786) was working on developing different types of pigments. In 1770, Scheele successfully created a yellow paint made from chlorine and oxygen. Unfortunately, the patent to this new yellow paint was stolen from him by a British manufacturer by the name of J. Turner (N/A), the yellow paint would go on to be called Turner's Patent Yellow. After the disaster of the yellow paint, Scheele went back to the drawing board and began experimenting with arsenic, developing a green pigment in 1775. Striving not to make the same mistakes as he did with his yellow paint, Scheele grabbed on to the patent associated with this new green and began to produce it under the name Scheele's green. Before his arsenic filled pigment went to market, Scheele began to have second thoughts about the pigment. He knew of its poisonous nature and felt the public should be informed of it as well. However, the potential of a great deal of money coming into him won out and Scheele kept silent about the pigment's deadly nature (Finlay, 26-392). Suspicions regarding Scheele's green in wallpaper date back as early as 1839. A German chemist, Leopold Gmelin (1788-1853), discovered that damp rooms would give off a nauseating odor which he labeled as the dimethyl arsenic acid found in the wallpaper. He published his findings in the Sunday edition of the "Karslsruher Zeitung", a daily paper, to try and reach the most amount of people, to warn them about the dangers of Scheele's green and the potential harm of having this pigment in their home (Haslam, 76-80). In 1880, Henry Carr (N/A) spoke out to the Society of Arts to speak about the dangers of arsenic pigments, questioning whether people even consider the fact that these

pigments, especially Scheele's green could be dangerous. Carr's evidence against Scheele's green was a scrap of wallpaper taken from the nursery of one of his young relatives. The young owner had recently passed away and their three siblings were seriously ill, all due to the arsenic pigment on the wallpaper. Many argued against Carr and stated that he was an alarmist. Arsenic pigments, like Scheele's green, were bright vibrant colors that could not be taken from their daily lives. One man went as far as to say that he would rather have the bright colors of pigments like Scheele's green over drab colors made without (Finlay, 26-392). Nearing the end of the 19th century, many people had begun to mistrust Scheele's green, both in the general public as well as the medical community. The National Health Society organized a bill banning the use of the pigment and all other arsenic filled items from the household. Today, Scheele's green is no longer in use or produced (Haslam, 76-80).

Scheele's green, also known as Paris green, is made with copper arsenite or cupric acetoarsenite. Some symptoms of what Victorian doctors called "chronic arsenism," better known as arsenic poisoning, include headaches, nausea, abdominal pains, and vomiting. Scheele's green has been confirmed as a known carcinogen (Environmental Health and Safety, 2017). Many sufferers of arsenic poisoning brought on by Scheele's green brushed off their symptoms as being the result of working long hours or insignificant. Scheele's green is highly toxic when absorbed through the skin but it is extremely toxic when it is inhaled or ingested. One of the first major cases involving Scheele's green, involved the death of 4 children. All of whom were a part of London's working class Limehouse district. At first, doctors wrote off their deaths as cases of diphtheria, a bacterial infection that effects the nose and throat. However, none of the children's homes showed signs of the infection and none of the other children in the neighborhood was infected, which would be the case if the illness was in fact diphtheria. Public

Health officer, Henry Letheby (1816-1876), made the discovery that all of the children's bedrooms contained green wallpaper treated with Scheele's green. Researchers measured the arsenic in the wall paper to be three grains per square foot, a lethal dose for an adult, and most certainly a child. Popular belief in the 19th century that the particles that brushed off of the wallpaper was responsible for the arsenic poisoning. There was a case of a three year old boy who had died from arsenic poisoning, and upon discovery, his body was covered with a fine layer of arsenic dust particles. Unfortunately, the favored medical practice of the time during the Victorian age, was confining someone to their bed. This was especially problematic in the case of arsenic poisoning because then the patient would be stuck in the room that was likely already killing him. Therefore, people were locked up with the thing that was slowly killing them. Arsenic poisoning can be reversed. There have been cases where once the Scheele's green pigment is removed from the wallpaper or the wallpaper itself is removed, the patient has fully recovered. In 1857, a physician named William Hinds (N/A) found himself having cramps and nausea on a regular basis. It baffled his mind that every evening he would feel these symptoms, only to have them go away as soon as he went to bed. Upon thinking about his routine and where he is at certain parts of the day, Hinds realized what the problem was. Every night before bed, Hinds would go to his Scheele's green wallpapered study and experience the symptoms, he would then proceed to his bedchamber where the symptoms would disappear. Hinds took samples from his wall discovering that his wallpaper did in fact contain arsenic leading to what he was experiencing. He proceeded to promptly remove all the wallpaper from the room and his health was soon restored (Haslam, 76-80). Following his recovery he has been quoted saying a "great deal of slow poisoning is going on in Great Britain" (Haslam, 77).

One of the reigning conspiracy theories surrounding Scheele's green is it being one of the main contributing factors leading to the death of Napoleon Bonaparte (1769-1821). Napoleon Bonaparte was a French military leader who rose through the ranks through his conquests, eventually proclaiming himself the Emperor of France. After his defeat at the Battle of Waterloo, Bonaparte was exiled to the island of St. Helena where he died at the age of 51. In 1960, what was believed to be a lock of Bonaparte's hair was bought at an auction and then chemically analyzed to discover whether the famous Emperor really did die of cancer, like the medical records indicate, or did Bonaparte succumb to the effects of arsenic poisoning through the Scheele's pigment painted on the wallpaper of his home on St. Helena? The results of that analysis are still unknown. A science program on BBC Radio, in 1980, once again brought up the idea that perhaps Bonaparte did not die of cancer as originally believed, but to prove this idea valid, a piece of the wallpaper from the room Bonaparte died in would need to be analyzed. Dr. David Jones (1938-2017), the chemistry professor who brought up the idea on BBC Radio, received a letter from a listener saying she had a piece of the wallpaper from the room on St. Helena. In the letter, the woman explains that she received the sample from an ancestor who had visited the house where Bonaparte died and stripped it off the wall. The strip of wallpaper featured green and gold fleurs-de-lis upon a white background. After testing the strip, Dr. Jones discovered that the piece of wallpaper did indeed hold traces of Scheele's green. He then did research into the island of St. Helena itself, noting that the environment was very humid and wet. Dr. Jones knew that the combination of a wet environment on the arsenic pigment would generate fumes, creating a very toxic situation. Records indicate that during the last months of his life, Bonaparte lay upon a camp bed in that gaseous room, hardly moving. Other research states that there wasn't enough Scheele's green in the wallpaper to have that much of an effect

upon the health of Bonaparte and the cause of his death was stomach cancer or sadness (Finlay, 26-392).

Emerald green first came into being as an attempt to improve the toxic and sometimes fatal pigment, Scheele's green. This pigment was first created in 1808 by Wilhelm Sattler (1784-1859) in Schweinfurt, Germany but wasn't commercially available until 1814 where it grew in popularity and quickly overcame Scheele's green. Its name 'emerald green' comes from the Latin word *smaragdus*, meaning precious stone. Other names known to emerald green are Paris green, Schweinfurt green and Veronese green. Emerald green projects a brilliant aqua to green color but it is largely unstable and very toxic, containing copper acetoarsenite, better known as arsenic. Its chemical formula is $\text{Cu}_3(\text{AsO}_4)_2 \cdot 4\text{H}_2\text{O}$. Emerald green was cheap to manufacture, which led to its popularity all the way to the early twentieth century. Andre Bracconot (N/A) and Justus Von Liebig (1803-1873) both separately wrote papers regarding the manufacture of emerald green. Von Liebig's paper "Sur une Couleur Verte," (On the Color Green), was published in 1823. It dictated that the production of emerald green actually began with the production of verdigris. Later, a watery solution of white arsenic was added, which created a dirt green solution. Fresh vinegar is then put into the pot in order to dissolve any remaining solid particles. The solution is then boiled to gain a bright aqua sediment, then separated from the liquid, washed, dried, and ground in linseed oil. This pigment is most commonly used in watercolors and can be found in most landscapes and sea paintings. Not only was this pigment used on an artist's palette, but it was a well-known household paint used on wallpapers. In a humid or damp environment houses soon become death traps of gaseous toxins. In the 1860's British newspapers tried to expose the problem of emerald green in households, to very little effect. What could be seen as most disturbing news of all, is that clothes of the nineteenth

century were dyed with emerald green. Men and women were walking around day to day minding their own business, while their clothes were slowly killing them. Researchers studying emerald green in clothing found large quantities in socks and green dresses. Many medical records of the time period support these claims (Douma, "Emerald Green," 2008).

The emerald green pigment can be distinguished from Scheele's green under optical microscopy because the pigment is seen as small uniformly rounded grains. Upon further magnification, the emerald green grains appear more radial in their structure. Through chemical analysis, emerald green is identified by a stannous chloride test. This test was originally created for the Scheele's green pigment but since both emerald green and Scheele's contain arsenic, they have the same reactions. When emerald green comes into contact with potassium hydroxide, it tends to take on a more ochre like appearance, whereas in sulfuric acid the pigment dissolves and changes into a blue color (Douma, "Emerald Green," 2008). The emerald green pigment is very toxic, especially when it is exposed to a damp or humid environment, creating a toxic gas. Emerald green is extremely toxic when ingested and inhaled so caution should be shown when handling or cleaning this pigment in its dry powder form. Extra steps should also be taken to make sure all work spaces are clean and that no food or drink should be in the same room as the pigment. This pigment is best avoided because it is highly toxic even when it comes in contact with skin. It is a known carcinogen and though it is not in use or manufactured anymore, any art object containing emerald green could be dangerous to anyone, especially in damp or humid environments (Environmental Health and Safety, 2017).

Fashion

Lewis Carroll (1832-1898) gained inspiration for his mad hatter character from the everyday working hatters of the 18th century. The cheapest and most inexpensive way to create

felt that would be later turned into hats would be to treat it with a mercury and acid solution. Hatters would take the hair from a pelt, usually hare, and “felt” it through friction, chemicals, and heat. Using a mercury, acid solution allowed for the breakdown of keratin proteins. This process is also called “carroting” because the hair would turn reddish orange in color (David, 42-69).

There are two legends on how hatters uncovered the fact that mercury would be the key ingredient in their felting process. The first begins with hatters working in France already using an acidic liquid to boil and felt their furs. To top off their solutions, hatters would often urinate into the solution. One hatter in particular began receiving a mercury compound injected into his penis as a medical treatment for syphilis. The felts coming from his particular shop became better and better than any other shop and hatters soon began adding mercury into their solutions. The second legend comes from Britain. It is said that a doctor created a poultice of rabbit fur, felted in mercury that cured a woman of breast cancer. A hatter then bought that pelt from the doctor, and seeing how nicely the pelt was felted, traced back its roots to discover what was done to it (David, 42-69).

Often, hatters wouldn't wear gloves while working with these raw materials. After years of exposure to mercury, hatters would develop clubbed hands and hand tremors due to oxygen deprivation, in America these tremors were known as Danbury Shakes. The Danbury Shakes are better known as Erethism, a neurological disorder caused by mercury poisoning that effects the central nervous system. Other health effects would include lung disease and heart conditions. Unlike pigments, often called silent killers, mercury and its dangerous effects were well known and public knowledge. In 1716, the hatter's guild banned the use of mercury but that proclamation did not last long and mercury was reintroduced. In fact, none of the bans on

mercury ever lasted long. One of the first doctors to study the health effects mercury had on the body, was Jacques-Rene Tenon (1724-1816) in 1757. His writings on the subject were numerous but largely unpublished. Many hatter shops took steps in protecting themselves from mercury poisoning through the use of masks and sponges. However, with the rise of the French Industrial Revolution, mercury's output was expanded significantly. Now found in both urban and rural hatter shops, the death toll continued to rise. A 41 year old hatter died of Delirium Tremens. A 61 year old hatter committed suicide by drinking his mercury felting solution. It was discussed that he may have had a mood disorder brought on by mercury poisoning. Some people even speculate that the mass epidemic of Acrodynia, better known as Pink's disease, was actually caused by mercury and not arsenic or lead, as originally thought. Pink's disease is seen in a pink discoloration of the hands and feet. Going into the late 19th century, many hatter business became split, with one factory designated for hatters, another for furriers, and yet another for fur-pullers. This greatly separated how hats were made but had little to no effect on how much mercury was used to make the hats. In 1912, public health officials tested a hat for its mercury content. It had 1 part per 800, which also equates to 1 ounce of mercury per 400 hats. By 1913, hatters were still using 20 kilos of mercury per 100 kilos of carroting solution, that's about 44lbs of mercury per 220lbs of solution. Medical studies shifted from just looking at the physical effects of mercury poisoning to the mental effects as well. Even into the 1940's, a study on hatters discovered that individuals still in the business at five different factories around Connecticut were still suffering from chronic mercury poisoning. Mercury also does not just effect the people working with it, it also effects the environment. During the Industrial Revolution, the soil of certain areas of Connecticut contained seven times more the amount of mercury that it should have (David, 42-69).

Today, in the Victoria and Albert Museum in London, textile conservators Graham Martin and Marion Kite discovered that their collection of hats, from 1820-1930, still held enough mercury to potentially harm anyone in charge of handling them. Though it was unclear as to how much risk these hats presented, Martin and Kite decided, as a precaution, to bag each individual hat in a reflective Mylar bag and place stickers on them depicting a skull and crossbones labeled “toxic” (David, 42-69).

Arsenic poisoning wasn't a rare thing during the 19th century. Many people suffered from it. Some may have passed it off as other illnesses but if you take a closer look at their lifestyle you will find, more often than not, somewhere in their daily life they worked with or interacted with arsenic multiple times a day. Arsenic greens came from Scheele's green, developed by Carl Wilhelm Scheele in 1775, or from Emerald green, created in 1808 by Wilhelm Sattler. These greens could be found on walls, toys, food, and clothes. They were technically green pigments rather than dyes because of their solubility. Pigments are insoluble whereas dyes can be dissolved by water. Fashion in the mid-19th century took a turn toward nature worship. During the 18th century, both men and woman would be seen in floral prints and vibrant brocades but by the 19th century it was mostly only women. Nature overtook their wardrobe, especially in their headpieces. Fruit, flowers, and foliage would adorn the heads of only the most fashionable women, and if they could not get the real thing in their hair, they would use artificial green dusted ones. The most popular floral headdress was called the “Dryad” after the beautiful mythological nymphs. It featured meadow and aquatic grasses as well as a central item on the diadem, often a butterfly. (David, 70-99).

November 20, 1861 an artificial flower maker named Matilda Scheurer (N/A-1861) died due to arsenic poisoning at only 19 years old. Ms. Scheurer worked for Mrs. Bergeron of London

organizing and altering artificial flowers. She then dusted them with an artificial green powder pigment that was also used for dresses, flowers, and other hair ornaments. Scheurer would work with this pigment powder every day, breathing it in and dusting it on her clothes that she would then wear home to cook her dinner. She was enveloped in the powder daily. Her illness was described in the daily paper and though her case was extreme, it was hardly a rare occurrence. Towards the end of her life, Scheurer complained that everything she saw looked green, the whites of her eyes held a greenish tint, she often had convulsions, and would eventually vomit green. It is thought that Scheurer suffered from arsenic poisoning found in the green powder she dusted on flowers every day (David, 70-99).

Flower making is an all year profession. Many women were interested in floral headdresses all year long. This took a toll on the men and women who worked in these shops. An 1829 artificial flower instruction manual encouraged workers to grind their own colors with a mortar and pestle. The author even suggested Emerald green as a prime pigment for the headdress leaves. It is very hard to work with dry pigment powder because even the slightest breeze can cause the powder to fly everywhere, getting into hair and clothes and traveling around to other places. The manuals fail to mention the deadlier side effects of these pigments. In Paris of 1856, many of these workers put in formal complaints regarding their working conditions, but little was done to resolve the issue. After Queen Victoria's likeness was captured in a watercolor portrait in 1855 wearing an emerald ball gown and artificial flowers in her hair, sales on both those items skyrocketed. Today, the Victoria and Albert museum holds in its collection, an 1850's flower making kit. The kit was tested and was found to still carry the same arsenic that would have been used to dust artificial flowers (David, 70-99).

Much like the artificial flowers, arsenic green pigments were being used to color women's dresses. The nature fetish of the mid-19th century had women dressing in green from head to toe, shawls, corsets, and gloves, among other items. The arsenic greens being used in clothing became commercially available around the 1820's. Some scientists speculate as to what where arsenic's origins could be. One possibility is that some of the white arsenic used to create the green pigments was taken from the tin smelting done by cobblers for shoes. Women wearing these green clothing would develop rashes and itchiness around the shoulder area, exactly where their dress sleeves might land (David 70-99). One report talks of a woman who bought a new pair of gloves and immediately, her hands broke out in blisters. Report began to flood in of women suffering from ulcers on their skin, hair loss, kidney failure, and vomiting blood. Women of the 19th century wore many layers under their dresses, even before the undergarments. This added an extra layer of protection from the toxins on the outer dress but women were still effected. Once the dye was sealed, it was much more difficult for the toxic pigments to leech out onto skin but it was still possible (Wright, 2017). In 1846, Jean Persoz (1805-1868), a chemist and professor, wrote a treatise arguing that the clothing industry had access to tests and equipment, like the Marsh test, that would allow for the testing and identification of these toxins but chose not to use it. This lack of action could be due to the popularity of the dress color. Many people did not make the connection between the clothes they were wearing and the toxins that were making them sick. Eventually, arsenic green dresses did die down in popularity. Women became the driving force behind the popularity of the dresses but also the decline, as they were the ones primarily buying these products. It is hard to tell whether the warnings regarding these dresses were finally making women act out or whether the style simply went out of fashion (David, 70-99). By 1895, factories began instilling regulations against working with toxins, like

arsenic, but by this time arsenic's popularity had downturned and it was almost off the market (Wright, 2017).

The museum of London and the Royal Ontario Museum combined their efforts and tested a green child's dress along with several other textile pieces in their collection. This cotton muslin child's dress was from the 1840's and it seemed to have been for a female child about 6-8 years old. It tested positive for arsenic but the tests performed on the dress were unable to quantify how much was present. This is a common occurrence as many dresses of the 19th century, when tested today, have a positive reading for arsenic. Arsenic sometimes isn't the only toxin found on some of these dresses, lead, potassium, copper, sulfur, and iron can be found as well. It could be that throughout the years the toxins found on these dresses have volatilized but they still possess enough toxins in them for positive readouts (David, 70-99).

Preservation and Pesticides

The mid-18th century brought about a wave of exploration and collecting. When Carl von Linne (1707-1778), better known as Carl Linnaeus, refined his system for classifying organisms, the need to amass large collections to study intensified. Items collected that contained organic materials would deteriorate at a quicker rate than others due to changes in temperature and humidity (Hawks, 2-11). Captain Charles Wilkes (1798-1877), along with other explorers would often add poisons to their collection items during expeditions in order to ensure they would last the return trip home and to a museum. Any wet specimens would be stored in alcohol and dry specimens would be treated with salts, heat, paint, or coated with arsenic or mercury compounds (Goldberg, 23-43).

The initial idea of using toxic materials as a preservation technique was first used on natural science collections. Later on, these treatments would include anthropology, ethnographic, and even botanical collections (Hawks, 2-11). Initially, salts, tobacco, herbs, and spices were used for a more natural way to preserve and protect collections, but they were found to be lacking and discarded. The more natural materials were soon replaced with stronger poisonous chemicals (Kehoe & Becker, 2017). Arsenic and mercury became the two more in demand preservatives but other were on the market as well, including borax, lindane, and naphthalene. Arsenic bar soaps were popular as taxidermy treatments whereas, arsenic, mercury, and bromine were used in natural history and anthropology collections (Sirois & Sansoucy, 49-66). Many of these powders and soaps were used on the inside of skins and a solution of it would be applied on the outside of the skin. As an alternative, skins could be submerged in arsenic coated sand (Sirois, 65-75). In 1770, Tesser Samuel Kuckahn (N/A-1776), a German naturalist based in Jamaica, sent four letters to the Royal Society in London talking about mercuric chloride as a preservative powder on the inside of the skins of birds (Hawks & Willams, 1986). Around 1825, Thomas Jefferson (1743-1826) gave many Native American artifacts from his collection, to Charles Willson Peale (1741-1827) for his museum in Philadelphia. This collection was originally gathered by Meriwether Lewis (1774-1809) and William Clark (1770-1838) during their exploration. Both Peale and Clark were known proponents of arsenic and mercury as a main preservation technique (Hawks, 2-11). It is unknown as to how Peale gained knowledge about arsenic as a preservative but it has been thought to have come from the works of Johann Reinhold Forster (1729-1798), to whom he was an avid follower. In 1831, many German museums began the push for arsenic to be used on mammals, birds, reptiles, and insect boxes. Walter Hough (1859-1935), an American Ethnologist, in 1889, wrote that mercuric chloride

washes should be utilized for the Smithsonian's anthropological and ethnographic collections. These collections would include items of basketry, woodwork, textile, and botanical (Hawks & Williams, 1986). The use of these toxic materials have left known residual contaminants on the collection objects. This results in the objects becoming hazardous when handled without the use of personal protective equipment and a possible carcinogenic. Over the years, collections have grown in numbers and have had to be moved into storage cabinets, mostly wooden, which begins a new set of hazards for people working in that collection (Hawks, 2-11). The toxins used to preserve the collections create case by case fumigation and gas-phase chemicals. This toxin based technique for the preservation of certain collection items remained prevalent well into the mid-20th century in some museums, with some records listing arsenic and mercury as pesticide treatments dating 1985. Many toxins used in the past now require a special license from the Environmental Protection Agency (Kehoe & Becker, 2017).

Two of the main toxins used in preservation of natural history, anthropological, and ethnographic collections, though not the only toxins used, were arsenic and mercuric chloride. Arsenic was the most recommended by explorers, collectors, and museums alike. There were three types of arsenic used, arsenic acid for liquid formulations, white arsenic or arsenic trioxide for use in the preparation of dry soaps and powders, and arsenite of potash for insecticide use. Smithsonian records from before 1940 detail the recipe used to create arsenic baths. Mercuric chloride, or corrosive sublimate was mostly used on cellulosic materials as a preservative and a pesticide treatment. Many objects could be dipped in a solution of mercuric chloride but most, including textiles in closed drawers, would be covered with crystalline mercuric chloride. Today, hazard tags containing a skull and cross bones or tags simply state the toxin are still dangerous and should not be handled without proper training and the use of personal protective equipment.

Arsenic and mercuric chloride were later traded for carbon disulfide, ethylene dichloride, and carbon tetrachloride (Goldberg, 23-43).

The most difficult part about going forward, in the modern age, with collection preservation and hazard assessment is that there are little to no records indicating what toxins might have been used on these collections. It is important that, before any testing occurs, research is done into the collections past preservation records. Museum staff handling these collection objects need to know if the object they are handling could potentially harm them (Sirois & Sansoucy, 49-66). Many natural science collections had arsenic and mercury preservatives put on the inside of skins, but over time those toxins can migrate to the outside of the skin, potentially harming someone not wearing proper personal protective equipment (Hawks & Williams, 1986). Some ways to try and discover what might have been used, is to interview old museum employees that worked with the collection and in-depth research into all the museum records pertaining to that collection. It is important to remember to document everything that happens to that object, including testing, cleaning, and other preservation techniques (Hawks, 2-11).

Testing for hazards in collections like, natural history, anthropological, or ethnographic can come in the form of sample or non-destructive tests. It is important to note that not all sample tests are destructive toward the collection piece, small samples can be taken with little effect on the overall piece. A spot test kit is a cost effective way to look for hazards in a collection at smaller, low budget museums. Some might say that this method is inferior compared to others because of its simplicity and its dependence on a sample. Some problems can arise from taking a sample from an object for testing, for cultural reasons, museums might not be able to take a sample from it, sometimes objects can be so small that there isn't enough of the

object to take a big enough sample from it, and finally, test samples from collection pieces have to be small enough that they are not noticeable to the eye of the visitor. When the test is complete, both it and the sample taken must be disposed of through proper means of hazardous disposal. The Gutzeit method is one of the best ways to test for arsenic or arsenic in a solution. The diphenylcarbazone test can be used to test for mercury, which was modified and developed by Steven Weber (N/A) for the purposes of the Carnegie Museum. This test requires its samples to be in powder or crystalline only. Finally, palladium chloride strips can be used to test for mercury vapor in storage cabinets. X-ray Fluorescence Spectrometry is a non-destructive method that looks at chemicals with an atomic number equal or greater than 20 percent. This qualitative method is strong enough to penetrate feathers to identify surface elements. However, it looks at elements not compounds and is not able to differentiate between whether the hazard is on the object, in its substrate, or inside the object. Being that it is portable, this method is a favorite among museums (Sirois & Sansoucy, 49-66).

One of the first published studies on the health risks in natural history collections was conducted by the Bristol museum. Their results discovered that their natural history collection held concentrations of 10,000ppm, or around 1%, arsenic as well as 0.01ppb found on the gloves worn by museum staff working with the collection (Sirois, 65-75). Alice B. Kehoe (1934-N/A) and Marshall J. Becker (N/A) asked David H. Thomas (1945-N/A), curator at the American Museum of Natural History, about pesticide use in museums. Thomas commented that the use of pesticides in the past is still a problem for museum workers, collectors, and those receiving objects of repatriation because of the chemicals used on them in the past. Any object brought into the American Museum of Natural History on loan is first examined by x-ray fluorescence to test them for toxins. Thomas mentions commonly seeing methyl bromide and mercury (Kehoe &

Becker, 2017). Many museums have pushed for a change to non-chemical preservatives largely because there is a greater awareness and understanding about the dangers some collections present as well as cleaner storage environments, and a better understanding of pest prevention (Hawks, 2-11). The Analytical Research Laboratory of the Canadian Conservation Institute conducted testing on 656 natural history specimens at an undisclosed museum. Objects from the collection were chosen by museum staff. Using a portable x-ray energy spectrometer for non-destructive analysis, researchers discovered that 81% of the collection contained arsenic and 5% contained mercury. Of their ornithology collection, 86% contained arsenic (Sirois, 65-75).

These are just a few examples of where toxic materials can be found in the collection. These items were either created with toxins or toxins were added on later to increase its worth on the market or as a preservation technique. Many museums hold in their collections examples of some, if not all, of the toxins? For a majority of museums, they are unaware of the dangers that these pieces still hold to people who handle them. Museums need to identify items in their collection that pose a risk for museum workers and then create a safety plan that works toward training and protecting their staff against these dangers.

Chapter V

Steps toward a Safer Museum Environment

Collection pieces created or procured before the mid-19th century were more than likely created or treated with a toxic material like mercury, copper, lead, or arsenic. Even today, these materials have the potential to be dangerous while on display or in storage. History is filled with records of people falling ill or dying with no probable cause in sight. Many of these cases could have been caused by toxic materials. Eva Hesse (1936-1970), a sculptor, famous for her work in post minimal art passed away at age 34 due to brain cancer. Brain cancer was the official stated cause of her untimely death, but many speculated that the toxic art materials she worked with, like resins and plasters, were the stepping stones that led to her demise. Michael Hall (N/A), a painter from San Francisco, suffered a particularly ruthless case of pneumonia due to the oil paints, solvents, and varnishes he would use in his work. Upon his return to health, he was quoted saying “I think a lot of artists end up creating problems for themselves, but they will not back down from it, they wear a badge of honor, they are suffering for their art” (Kraft, 2). In recent years, the harmful effects of these toxins in museum collection are slowly being communicated to the public more openly and non-toxic alternatives are being discovered every day.

When working in a museum setting, it is always important to identify and locate any hazardous, or potentially hazardous collection items. By identifying these hazards, employees of museums are not only protecting themselves, they are also protecting museum visitors and the collection itself. Hazards to people begin when the object is first encountered by someone. Hazardous collections include any items that have the potential to cause harm to someone. Harm can mean illness, or injury. When identifying hazards, it is important to look further into what is

a hazard versus what is a risk (Schrager et al., 2016). Hazards in museums are not always obvious, some are hidden in object construction or in what was used on these items to help preserve them (Makos & Skimina, 2003). Museums cannot display historically significant objects or artifacts without first examining if the object is a hazard or how they might reduce the risk it may cause. By reducing the hazard, museums reduce the risk of exposure to employees and visitors (Schrager et al., 2016).

Hazardous collections can be inherent or acquired. Inherent collections can be hazardous because of the material it is made with, meaning it is hazardous without intervention. They can be plants, pharmaceuticals, heavy metals, radioactive metals, or chemistry sets. They can cause physical harm but the dangers behind them may be overlooked as insignificant. Hazardous materials on the objects themselves were often added for value or to enhance its basic nature. In the case of pigments, many toxins were added to enhance the pigment's durability and brilliance. Some examples can be arsenic or lead in weighted silk, cadmium or lead in pigments (Schrager et al., 2016).

Acquired collections are as the name would suggest. The hazards in or on the object have been acquired through treatment, deterioration, or environmental influence. Arsenic, formaldehyde, and Naphthalene were popular pesticide and preservative treatments that can be found on many objects in a museum's collection. Many lead and cadmium based paints can powder over time, flaking onto other objects or people walking by. Many medicine and film chemicals can deteriorate over time and create off-gas. Acquired collections containing hazards created by environmental conditions can, for the most part, be predicted. The accumulation of mold, bird droppings, soot, or lead paint can be predicted based on humidity controls, storage accommodations, and surrounding objects (Schrager et al., 2016). A big problem with the

identification of hazards in collections is not knowing what was done to the object in the past. Many museums may have detailed records regarding what happened to that object while under their care but that object had a whole other life before living in the museum, someone could have tried to protect the object using methods that now could make that object hazardous. While explorers of the 18th and 19th centuries were discovering new cultures and creatures, they need a way to make sure these items would survive the trip home and to the museum. Toxins used as preservatives would be added (Hawks & Makos, 2003).

Having a safe collection and a safe staff go hand in hand. Museums need to create a safety plan outlining any disaster planning, occupational health and safety, accessibility to guests, and risk management. By creating a safety plan, museums are able to identify potential hazards in their collection. They are then able to implement different techniques to combat any hazards. This is also important to have in place so that when a new object comes into the collection that contains toxins, the museum does not have to go back to square one and develop new preventative action to protect their staff and visitors. Having some sort of safety plan covers the museum legally if anything should happen to one of their employees because of a toxic object in their collection. Finally, and most importantly, having a safety plan creates a safe environment for everyone and allows staff and visitors to enjoy the objects in the collection (Schrager et al., 2016).

Unfortunately, many museums do not have any sort of plan in place and often times do not even think about that fact that this could be a real problem. The American Alliance of Museums does require museums to create core documents that encompass different aspects of the museum. Under these core documents are collection management policies and disaster preparedness plans. Neither of these documents, however, seem to address toxic materials used

to create or added on later to objects, though it may be argued that they fall under risk assessment. The museums that fall under the American Alliance of Museum, though many, do not encompass all museums (“Core Documents,” 2018). In an effort to understand what policies museums of different disciplines have in regard to toxic materials in collections; a survey of eight questions were sent out to museums across the United States. Various occupations, such as curator, researcher, collections manager, and conservator, within the museum were questioned.

Questions included;

- Do you currently or have in the past housed artwork made/created with toxic materials in your collection?
- What is your museum’s policy on accessioning artwork that was made/created with toxic materials?
- How are toxic materials already in the collection identified?
- What safety precautions do you have in place in regards to storing and care of said object/s?
- What safety precautions do you have in place when putting said object/s on display?
- Do you have any policies or training in place for employees prior to engagement with said artefact?
- Do you allow the artefact containing toxic materials to be loaned out to other institutions?
- Are your policies on display for public consumption?

Surprisingly, responses to the survey were few and far between. Twenty three museums were emailed and from that only nine answered. In the end only four of those nine provided any

information beyond saying they could not help. From the four that answered come different points of view based on their job. There was a chief curator, a senior curator, a deputy director of curatorial affairs, and a collections manager.

Responses were all very similar in that none of the museums knew what they had in their collection specifically regarding toxic materials. Nor did they have any policies regarding these toxic materials. One curator commented with more of an explanation as to why his museum might not have such a policy. He stated “We do not have a policy on the handling or presentation of works that may contain toxic materials, and we’ve never been approached by any other museum or visitor about toxic materials. Since we have a do not touch policy, and since staff wears gloves when handling objects, we have not perceived a problem.”

Museums must think about is whether gloves offer enough protection for staff members handling objects made with toxic materials. Cotton gloves may offer the solution to handling these objects safely but they may not stop the toxins from the object from seeping into the gloves for the next person who wears them. Many curators caution against latex or rubber gloves because they can cause allergic reactions for many people and they pose the risk of leaving residues on the objects themselves. Nitrile gloves are being used more often in curatorial work and seem to be the new go-to glove because they protect against a large spectrum of chemicals and they are disposable. It is important for anyone handling objects to make sure that not only are they using the correct glove for the situation, but also that their gloves fit properly and they are the correct thickness, as to not let any toxic materials have the possibility of penetrating the glove. The National Park Service’s *Conserve O Gram* presented the article “How to Select Gloves: An Overview for Collections Staff,” which features a graph of the many different types of gloves and the pros and cons of each. It is an additional resource museums can utilize when

trying to determine which glove is prudent for each situation (“How to Select Gloves: An Overview for Collections Staff,” 2010).

In an effort to create a safety or risk management plan to avoid any health hazards to visitors or staff, there are four important pieces to consider. The first is the assignment of responsibilities. It is important in any situation to know what your role is and who you can go to with questions or concerns. Any employees in management, administration, or supervisor roles are going to carry the most responsibility and be expected to carry out any safety guidelines and training needed to protect their employees. Having staff members know their role in dealing with hazardous materials can lead to good hazard communication. When a hazard has been identified every job inside that museum will have some sort of responsibility when dealing with discovery, treatment, and care. Those members who are in administrative and registrar roles are in charge of research, isolation, sampling, housekeeping, and environmental monitoring. The collections manager is in charge of looking into protective equipment, updating the collection’s policy, and the rehousing of the item. Conservators head the treatment, testing, identification, and isolation of the hazardous item. Finally, any specialists on the scene are responsible for any removal of bad components, and having any replicas made (Schrager et al., 2016). Even buildings and grounds departments have certain responsibilities. One curator writes “Our buildings and grounds department has detailed policies they follow for handling chemicals and other substances used for cleaning and maintenance.”

Once an incident has occurred there are more responsibilities for staff members. Those in roles of higher responsibility will need to make sure they are in constant communication with any fire, safety, or environmental professionals. Any volunteers, interns, or consultants of the museum will be responsible for knowing and carrying out any safety guidelines. The

environment in the museum must be one of open communication and leading by example. This extends to other museums and their staff. When shipping any items from the collection, especially paintings made with toxic pigments, information regarding the toxins and proper care and display procedures should accompany the artifact throughout its voyage (Schrager et al., 2016).

Next is hazard identification. This is difficult to accomplish because of the vast quantity of objects museums can acquire. The greatest challenge that museums face when trying to identify hazards in their collection is knowing what is in their collections. The majority of museums are going to have hundreds to thousands of objects in their collection, making it nearly impossible to filter through each piece in order to understand whether it is toxic and poses a risk to employees or visitors. Hazards in collections can also be assessed in different ways. There can be items in a collection that were created with toxic materials but no longer cause a threat to anyone handling it. For example, glass is often made with silica but does not possess enough of the toxic material to be harmful to anyone. The same is true for Vaseline Glass, which is made with uranium but poses very slim to no threat of radiation. The senior curator dug into her institution's collection, asking curators and collections managers, anyone who worked closest to the objects, whether they knew if their collection contained any toxic materials. Stated: "No one is aware of any artworks in the collection that are made with toxic materials." The deputy director of curatorial affairs at the New Orleans Museum of Art, said "As far as I know, we do not have any works created from toxic materials in our collection." Some museums have only vague understandings of what they have. As one curator said "We do have objects that contain lead, such as paintings worked with early lead-based paints, metal objects (which often contain

traces of lead), and the leading in early stained glass windows. There is also mercury in our thermometers.”

Records should be kept and updated throughout the life of the object within the museum’s collection. If the object becomes deaccessioned for any reason, that hazard identification material should go with the object. Testing the collection for hazards should not damage the object. Each test done on an object should be tailored to be the best test for it without harming the object. With that said, it is important for museums to know and understand the composition of their objects. When testing for particulate and organic residues, testers can utilize filter wipes, micro-vacuuming onto a filter cassette, spot testing with indicator papers, portable x-ray fluorescence, or gas chromatography- mass spectrometry. For testing vapors, using direct reading devices are most commonly used, like indicator papers and evacuated canister bag samples. Indicator papers, and ultraviolet light are utilized when testing for radiation (Schrager et al., 2016).

The Occupational Safety and Health Act organization, or OSHA, is responsible for testing of hazards at different work locations. Museums might also look into the possibility of learning how OSHA tests for different hazards and acquire the necessary testing materials to do it themselves. This could be an inexpensive alternative for museums on a tight budget but in need of hazard identification. Another resource museums should access are industrial hygienists. Industrial hygienists are people who are trained to recognize and prevent environmental factors in workplaces that could cause illness or other related health effects. Many are scientists and engineers who investigate workplaces in order to discover any potential risks or hazards. They offer training and educational resources for anyone needing more information on hazard

identification and they perform follow up visits to evaluate how things are improving or whether further action needs to be established (“Discover Industrial Hygiene”, 2018).

Unfortunately, the downside to testing the objects is that it only identifies the material in the object, not the risk the object might pose toward staff members and visitors. It does not take into account the rate of transfer between hazards and people. Basic understandings of the hazards found in or on the object as well as knowledge of how the hazard operates in different environments can help to estimate the rate of transfer. For example, arsenic becomes gaseous in humid environments. Hazard identification extends beyond the collection, to the building’s construction as well as anything used in the display of the collection. Many museums are located in older buildings which could still contain lead paint. If the materials are unknown, whether it be a collection object or a wall paint, scientific testing performed by professionals is always recommended (Schrager et al., 2016). Something to also think about is the hazard identification of objects coming into the collection. The collections manager of the Louisiana Art and Science Museum says “If an object was offered for accessioning into our collection that was made of toxic materials we would have to judge our votes very carefully. Our committees and board would consider the danger of the object, how it might be housed to keep it and our staff safe, and how well it fit into our collection mission. I would venture to say that something dangerous/toxic would have to be in excellent if not perfect fit for our collection before we would even consider bringing it into our facility. An object that is dangerous to staff, to other items in the collection, or even to itself would likely prove to be more risk than a typical collection institution is willing to take on.”

The third and possibly the most important piece of a safety plan is hazard communication and training. Communication about hazards is often found through written memos, records, and

alerts. Written fact sheets should be found in areas where the hazardous objects are located. These locations can also have write ups about safe practices when handling the object. Warning signs and labels need to be in the same area or on the object in question. Records should be kept detailing the hazards associated with the object and those records need to be updated as time goes on. These records are actually required under the Occupational Safety and Health Act, or OSHA. Restrictions need to be in place and communicated to staff and visitors blocking them from areas in which hazards could pose a risk or areas of poor ventilation. In the case of toxic pigments, paintings should be kept behind glass in a controlled environment when displayed to avoid flaking and off-gassing. Paintings in storage should be kept in a controlled environment, and particular attention should be paid to whether flaking is accumulating on the floor or onto other paintings. All staff members, from volunteers to the highest official, should undergo basic training on how to deal with different hazards. Training should be conducted by a professional. If help is needed on where to find professionals, the Occupational Safety and Health Act is required to provide resources for you. Safe work practices should always be in place to reduce any harmful residues. Protective equipment should also be utilized, like goggles, gloves, respirators, and lab coats. Under OSHA, employees are able to legally decline to work with any and all hazardous materials they could come across in the collection (Schrager et al., 2016).

The Occupational Health and Safety Act (OSHA)

Museums, in addition to other institutions, must observe certain laws that aim at the health and safety of their visitors. However, safety for their visitors starts with their employees. The Occupational Safety and Health Act, (OSHA), is a set of standards put out by the government to ensure that each and every employee working in certain industries are protected on the job and that the proper training is provided to ensure that protection. Many of the

standards set in place by this act focus on big industries and manufacturing companies but it also applies to the small institutions that could have hazardous materials. Many museums house objects that have been created or treated with hazardous materials. Using OSHA guidelines is just one way that museums can provide necessary safety measures to protect their staff from the hazardous materials, which in turn protects the visitor ("Occupational Safety and Health Act (OSHA) of 1970" 2008).

The concept behind OSHA was conceptualized of by President Lyndon B. Johnson (1908-1973) in 1968. Johnson felt that because of the U.S.'s success in being an industrialized nation, stricter regulations on the safety of its workers should be addressed. However, he was not able to push the idea through congress. His successor, Richard Nixon (1913-1994), was able to sign the bill on December 29, 1970 and it was established by the Department of Labor in 1971 (Wallechinsky, 2016). The original standards set out by OSHA were published in the Federal Register on May 29, 1971. It included some existing standards, national consensus standards for general industries, as well as standards for other industries like maritime, and construction. These new OSHA standards were set to be put into effect August 27 of that same year. This allowed businesses a 90-day grace period in which to align themselves with the new standards (Zaske, 3-6). The years following OSHA's foundation were quite rocky. Critics blasted the organization saying they were too inconsistent when it came to enforcing health and safety regulations. Many big companies also took shots at OSHA because they did not want to have to follow the regulations put forth by the organization (Wallechinsky, 2016). OSHA has 10 regional offices, 49 area offices, and 2 maritime offices, all of which are spread throughout the United States (Zaske, 3-6).

The Occupational Safety and Health Act ensures that employees as well as employers throughout the United States in addition to the United States' territories are provided a state approved job safety and health plan. OSHA standards apply to individuals in manufacturing, agriculture, law, medicine, charity and disaster relief, organized labor, and construction among others. OSHA even includes a separate area for federal government employees and state and local government employees. The act does not cover farms that only employ family members or self-employed individuals. OSHA standards can be grouped into four categories, general industry, maritime, agriculture, and construction. Each standard set out by OSHA can apply to one industry or to all. They are interchangeable ("Occupational Safety and Health Act (OSHA) of 1970," 2008).

The OSHA hazard communication program encourages all employers to install this four part program. First, employers must establish a written hazard communication plan. This plan also has to be maintained. Then, employers must inventory what hazardous materials they have. Next, employers must develop a labeling system that communicates the original manufacturer's containers as well as any secondary containers used to distribute the materials. Finally, employers must make sure employees have adequate training regarding the safe use of any hazardous materials ("Health & Safety Labeling...", n.d.). The United States Department of Labor's website holds the OSHA Occupational Chemical Database. This database gives any information pertaining to a certain chemical. Visitors to the site are able to look up a chemical's identification, physical properties, exposure limits, and emergency response information. Updated as of June 2006, the database features a pocket guide to chemical hazards. This guide discusses personal protection and sanitation, first aid, protective equipment recommendations, exposure routes, and symptoms ("Occupational Safety and Health Act (OSHA) of 1970" 2008).

This act has two functions, setting standards for employers to provide adequate safety and health plans and conducting inspections to make sure employers are adhering to the set standards. It is important that employers are familiar with the standards set in place by OSHA so that they comply with all of the regulations. These regulations make sure that employees are provided with adequate training in dealing with situations that involve hazardous materials and making sure that employees are provided protective equipment while working with these hazardous materials (“Occupational Safety and Health Act (OSHA) of 1970,” 2008).

In terms of protective equipment, each industry will have its own protective equipment that pertains to it. In the museum field, protective equipment can include ventilation masks, fume hoods, and eyewear, among other items. Standards also require employers to conduct hazardous material evaluations on any location inside their institution where those items are placed. Those locations as well as any new locations must communicate that they are hazardous. This can be accomplished through labels and signs in addition to memos given to every personnel member. This allows employees to either avoid the hazard or prepare themselves with the necessary equipment to work with the hazard (“Occupational Safety and Health Act (OSHA) of 1970,” 2008). Accidents involving hazards can happen very easily. Dartmouth College chemistry professor Karen Wetterhahn (1948-1997) was working on a routine experiment involving dimethyl mercury when a few drops fell upon her latex gloves. Wetterhahn thought that she had adequate protective equipment and therefore did nothing. However, it only took 15 seconds for the mercury to soak through her glove and into her skin to her bloodstream. Within six months, Wetterhahn could not walk, hear, or speak. She had severe brain damage and tests conducted on her hair showed 4,200 times the amount of mercury it normally should. Before Wetterhahn died,

at the age of 48, she wanted her story to be an example and a starting point toward advocacy against mercury poisoning and the recognition of proper protective equipment (David, 4-27).

Employers, covered by OSHA, have over 10 people working under them must have three types of records, indicated through OSHA, that detail job related injuries and illnesses. Industries that have low hazard levels, like retail, insurance, and some service sectors are exempt. Exempt employers also include organizations with fewer than 10 employees in low hazard industries. OSHA has two different forms for work related injury/illness and individual incident reports, Form 300 and Form 301. Employers are urged to contact the nearest OSHA office within eight hours of an incident that results in one or more fatalities. OSHA will then conduct their own investigation into the situation to determine whether OSHA standards had been violated which could have led to the incident ("Occupational Safety and Health Act (OSHA) of 1970," 2008).

Consumer Product Safety Commission (CPSC)

The United States Consumer Product Safety Commission (CPSC), established in 1972, is an independent federal agency that works toward protecting the public from dangerous products sold in the United States. In a similar fashion to the Occupational Safety and Health Act, the CPSC develops standards for industries to enforce and offers penalties for violations as well as enact product recalls. However, unlike OSHA, the CPSC can ban a product if there are no standards that fit the dangerous product. This is to ensure the protection of the public from harm. The CPSC is constantly conducting research into potential hazards that could come from various consumer products. Products that fall under the radar of the CPSC are products that could catch fire and products with any chemical, mechanical, or electrical hazard associated with it. They are especially concerned with any product that holds the potential to harm children (Wallechinsky, 2016).

Before the CPSC was established, there were few standards or laws that could hold manufacturers or big industries accountable if their product caused harm or killed someone. There was the Flammable Fabrics Act of 1953, which protected the public from fire. The Refrigerator Safety Act of 1956 was established due to the deaths of many children who suffocated when the door shut on them. This act required the producers of refrigerators to install doors that could easily be opened from the inside. The Federal Hazardous Substance Act of 1960 set out to make sure every manufacturer was required to label anything made with hazardous materials. Hazardous substances could be anything that can cause harm to someone while handling or using the product. Finally, there was the Poison Prevention Packaging Act of 1970, which required special packing on product contain dangerous materials to protect children from them. None of these laws were put into motion backed by an agency of any kind. They were all just there. So in 1970, the National Commission of Product Safety was established to examine all the products sold on the American market and analyze them with safety in mind. After years of having a different law for everything imaginable, the Consumer Product Safety Commission was created in 1972, putting all those other laws under one roof (Wallechinsky, 2016).

Today, the CPSC is controlled by five commissioners who are nominated by the President and confirmed by the Senate. Their staggered terms each last seven years. Through time, the CPSC has come under scrutiny and controversy with critics saying they are not doing enough to protect the public's interest and safety. So on August 14, 2008, President George W. Bush (1946-N/A) signed into law the Consumer Product Safety Improvement Act. This update makes sure that testing requirements are put in place and utilized, that penalties occur when companies violate the set standards, and established a database that provides product information

and a space to report violations. This databased was launched on March 11, 2011 (Wallechinsky, 2016).

From the 1950's through the 70's artists would experiment with untested industrial materials for their art. None of these materials held labels identifying what they were or what hazards they contained. Many artists would work with these industrial toxins without the proper protective gear as well. Under the Consumer Product Safety Commission, the Labeling of Hazardous Art Material Act (LHAMA) was put into motion, November of 1990. This act controls all the labeling of hazardous art materials that falls under the Consumer Product Safety Commission. LHAMA's purpose is to communicate with consumers about the potential short and long term effects associated with hazardous materials through an ASTM standard. The ASTM D-4236 standard was developed by a subcommittee of the American Society for Testing and Materials. It states "Since knowledge about chronic health hazards is incomplete and warnings cannot cover all uses of a product, it is not possible for pre-cautionary labeling to ensure completely safe use of an art product" ("Health & Safety Labeling...", 1). It is important to be careful when handling any product that might contain hazardous materials because even though it conforms to the ASTM D-4236 standard, it does not always mean the product is non-toxic. A product having the D-4236 label just means that it has been examined for the potential of any acute or chronic toxicity effects. The label must also indicate all the ingredients in it that could be a potential health hazard. Finally, products with labels indicating a health hazard, must also include instructions for safe use. If there is any question about whether a product includes a health hazard, the Consumer Product Safety Commission will prepare and distribute a material packet full of informational and educational resources and materials ("Health & Safety Labeling...", n.d.).

A way that manufacturers can make sure they are staying on top of LHAMA is to apply for the ACMI product certification program. The ACMI product certification program was created by the Art and Creative Materials Institute, Inc. For over 70 years, this association has grown to encompass close to 200 art and creative material manufacturers internationally. Each of these businesses strive to educate and encourage safe practices by offering a certificate program that produces labels that indicate their products have been inspected for hazardous materials. This program has developed since its inception to include a larger range of products, including adult art supplies as well as children's. ACMI's certification program is constantly trying to update their scientific methods as well as any recent regulatory information that may have been released. The program also considers all the regulations regarding the ASTM D-4236 standard. All in an effort to make sure their information is current and accurate in order to keep you safe. Every five years, the ACMI conducts a review of all the formulations given on products to make sure they line up with the requirements set forth by the Labeling of Hazardous Art Materials Act ("Home," 2017).

There are two different labels that can be affixed to children's and adult's art supplies, the AP (Approved Product) seal and the CL (Cautionary Product) seal. Products bearing these seals have undergone extensive examination by certified toxicologists and adhere to all federal and state laws. Testing of products include identifying any sign of potential acute or chronic illnesses or infections. The AP seal shows that the product has gone under extensive toxicology testing and was found to non-toxic or have an insufficient quantity of toxins that could be harmful to children or adults. Art materials featuring the CL seal have been tested and have been found to contain toxins that could be dangerous to someone's health if not used properly. These products are properly labeled with information about the hazards inside of them as well as information

regarding the safe and proper use and handling of the product. It is important to read all of the information on the label before handling the product. Products with the CL seal should never be given to children or to anyone who cannot understand what the safety label is communicating to them. Only a small amount of adult art materials feature this seal and none of the children's art materials have it ("Home," 2017).

The final piece to consider when creating a safety plan is exposure assessment. This assessment is often done by professionals. Though it might get pricey, it is always better to put the money up front now than have to spend more in damages or legal fees later. Industrial hygienists or safety specialists are good resources to call upon or healthcare professionals that specialize in testing biological monitoring. Periodic primary care doctor visits are also recommended for any museum staff member working with hazards. Bio-monitoring for all routes of entry, besides inhalation, can be accomplished through frequent blood or urine samples. If staff members are working with arsenic, weekly urine samples are recommended. Even if arsenic is not showing up in other tests, it should show in a urine test. Exposure to other hazards can be tested through air samples, for inhalation, and wipe samples, for ingestion and absorption. Having items in a collection that are hazardous can be a lot of work and unfortunately HEPA filtration vacuums only clean the air so much. Other toxins can develop or worsen due to other factors. The solution to this problem could be to replicate the item, digitize it, or deaccession it entirely. The Environmental Protection Agency's website provides locations of various waste drop-off sites as well as resources about hazard consultations and often communicates the latest research in hazardous waste materials (Schrager et al., 2016).

Chapter VI

Conclusion

In conclusion, exploring the use of toxins in museum collections is not a new idea. Toxins in pigments have been around since the time of the Egyptians. The Industrial Revolution saw an increase in the use of arsenic in fashion as well as its introduction as a preservation technique. The majority of these collection pieces are still harmful to anyone handling it and many museums do not know that their collections contain them. The majority of museums are going to have hundreds to thousands of objects in their collection, making it near to impossible to filter through each piece and discover what it was created with. What this means is that museums need to begin the necessary steps to test and identify parts of their collection for toxins. Then they need to create safety plans and work with organizations already set up to train and protect their employees who work with these objects.

The four main contributors to toxic pigments are arsenic lead, copper, and mercury. All four of these toxins are featured in many collection pieces in various forms, such as mercury sulfide, copper arsenite, lead tetroxide, and lead chromate. Certain toxins are more dangerous in various environments. If those environments are found inside the museum everyone within the object's radius will have various levels of exposure. Small doses of these toxins in a body build up over time and can cause major health risks. Smaller museums with limited funds can access resources and test kits available for them to test their collections and find new ways to protect staff members. The resources and knowledge is available, and it needs to be always utilized more effectively.

Museums need to create policies and enact training to protect their staff members as well as their visitors. One such policy can be a safety plan outlining any disaster planning, occupational health and safety, accessibility to guests, and risk management. Museums are then able to implement different techniques to combat any hazards. Having some sort of safety plan covers the museums legally if anything should happen to one of their employees because of a toxic object in their collection. Most importantly, having a safety plan creates a safe environment for everyone and allows staff and visitors to enjoy the objects in the collection.

Through the combination of identifying what hazards are found in certain areas of the collection, their characteristics, and discussing what policies museums have in place regarding toxic pigments, museums are then able to protect themselves legally, their staff members, and their visitors from the dangerous health effects toxic materials can pose in a collection.

Works Cited

- Alice B. Kehoe and Marshall J. Becker, "Arsenic and Old Pelts: Deadly Pesticides in Museum Collections," *History of Anthropology Newsletter* 41 (2017):
<http://histanthro.org/notes/arsenic-and-old-pelts/>.
- Allen, Will. *The War on Bugs*. White River Junction, VT: Chelsea Green Pub., 2008. Print.
- Alpha Gallery. "Reed Kay." Reed Kay- *Alpha Gallery*. Alpha Gallery, 2017. Web. 18 Mar. 2017.
- Armitage, F. *The British paint industry*. Oxford: Pergamon Pr., 1967. Print.
- David, Alison Matthews. *Fashion Victims: The Dangers of Dress Past and Present*. London: Bloomsbury Visual Arts, 2015.
- Douma, Michael, curator. "Emerald Green." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 29 Apr. 2017.
- Douma, Michael, curator. "Intro to the Blues." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 24 May 2017.
- Douma, Michael, curator. "Intro to the Greens." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 29 Apr. 2017.
- Douma, Michael, curator. "Intro to the Reds." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 16 Apr. 2017.
- Douma, Michael, curator. "Lead White." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 18 Apr. 2017.

- Douma, Michael, curator. "Naples Yellow." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 5 May. 2017.
- Douma, Michael, curator. "Red Lead." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 18 Apr. 2017.
- Douma, Michael, curator. "Vermilion." *Pigments through the Ages*. 2008. Institute for Dynamic Educational Development. 18 Apr. 2017.
- Elert, Glenn. "Color." *The Physics Hypertextbook*. The Physics Hypertextbook, 2017. Web. 14 June 2017. <physics.info/color/>.
- Environmental Health and Safety. "Painting & Drawing Pigments." *Painting & Drawing Pigments* – CSB/SJU. College of Saint Benedict Saint John's University, 2017. Web. 6 Apr. 2017.
- Finlay, Victoria. *Color: A Natural History of the Palette*. New York: Ballantine Publishing Group, 2002. Print
- Goldberg, Lisa. "A History of Pest Control Measures in the Anthropology Collections, National Museum of Natural History, Smithsonian Institution." *Journal of the American Institute for Conservation*. Vol. 35, No. 1. 1996.
- Guillory, Lexi. "Master's Thesis Research Questions." Email Interview. 12 Apr. 2017.
- Haslam, Jessica Charlotte. "Deadly decor: a short history of arsenic poisoning in the nineteenth century." *Res Medica* 21.1 (2013): 76-80. University of Edinburgh's Journal Hosting Service, 2013. Web. 24 Apr. 2017.

Hawks, Catharine. "Historical survey of the sources of contamination of ethnographic materials in museum collections." *Collection Forum*. Vol. 16. No. 1-2. 2001.

Hawks, Catherine and Kathryn Makos. "Inherent and Acquired Hazards in Museum Objects: Implications for Care and Use of Collections." *CRM* 23(5): 31-37. 2000. Web. February 2018.

Kay, Reed. "The Painter's Guide to Studio Methods and Materials." *Notebook*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983.

Kehoe, Alice B. and Marshall J. Becker, "Arsenic and Old Pelts: Deadly Pesticides in Museum Collections," *History of Anthropology Newsletter* 41 (2017):
<http://histanthro.org/notes/arsenic-and-old-pelts/>.

Kraft, Jessica Carew. "Toxic Art." *East Bay Express*. East Bay Express, 23 Mar. 2011. Web. 13 Sept. 2016.

Lee, Janice S., and Santhini Ramasamy. "Arsenic." *Hamilton and Hardy's Industrial Toxicology*. 1st ed. N.p.: John Wiley and Sons, Inc., 2015. 45-52. ProQuest. Web. 15 June 2017.

Lucas, Jim. "What is Visible Light?" *Live Science*. Live Science, 30 Apr. 2015. Web. 14 June 2017.

Makos, Kathryn A. and Margaret Skimina. "Hidden Hazards: Health and Safety in Museums and Art Galleries." *The Synergist*. American Institute for Conservation. 2003. Web. February 2018.

McCombs, W. Douglas, PhD. "Master's Thesis Research Questions." Email Interview. 10 Apr. 2017.

Mecklenburg, Virginia. "Master's Thesis Research Questions." Email Interview. 12 Apr. 2017.

National Center for Biotechnology Information. PubChem Compound Database; CID=23931,
<http://pubchem.ncbi.nlm.nih.gov/compound/23931> (accessed 6/27/17).

National Center for Biotechnology Information. PubChem Compound Database; CID=23978,
<http://pubchem.ncbi.nlm.nih.gov/compound/23978> (accessed 6/25/17)

National Center for Biotechnology Information. PubChem Compound Database; CID=5352425,
<http://pubchem.ncbi.nlm.nih.gov/compound/5352425> (accessed 12/14/16).

National Center for Biotechnology Information. PubChem Compound Database; CID=5359596,
<http://pubchem.ncbi.nlm.nih.gov/compound/5359596> (accessed 6/27/17).

Rotondo-McCord, Lisa. "Master's Thesis Research Questions." E-mail interview. 12 Apr. 2017.

Sanderson, R. Thomas. "Arsenic (As)." *Encyclopedia Britannica*. Encyclopedia Britannica Inc.,
20 Oct. 2014. Web. 24 June 2017.

Schrager, Kerith Koss, Anne Kingery-Schwartz, and Kathryn Makos. "Arsenic & Old Lace:
Controlling Hazardous Collection Materials." Audio blog post. *Connecting to
Collections*. Foundation of the American Institute for Conservation of History and
Historical Works, 3 May 2016. Web. 6 Feb. 2017.

Sirois, P. Jane. "The analysis of museum objects for the presence of arsenic and mercury:
Nondestructive analysis and sample analysis." *Collection Forum*. Vol. 16. No. 1-2. 2001.

Sirois, P. Jane, and Genevieve Sansoucy. "Analysis of museum objects for hazardous pesticide
residues: A guide to techniques." *Collection Forum*. Vol. 17. No. 1-2. 2001.

Thomas, Anne Wall. *Colors from the earth: the artists' guide to collecting, preparing, and using them*. N.Y.: Van Nostrand, 1980. Print.

Varichon, Anne. *Colors: what they mean and how to make them*. Trans. Toula Ballas. New York: Abrams, 2006. Print.

Wallechinsky, David. "Occupational Health and Safety Act of 1970." *All Gov: Everything our Government really does*. IT Labs, 2016. Web. 5 July 2017.

Williams, Fay. "Lead." *The SAGE Encyclopedia of Cancer and Society*. Ed. Graham A. Colditz. Thousand Oaks: SAGE Publications Inc., 2015. The SAGE Encyclopedia of Cancer and Society. SAGE Knowledge, 25 Aug. 2015. Web. 12 Jan. 2017.

Zaske, Sara. "The hidden life of art supplies." *Sierra*, Jan.-Feb. 2003, p. 3-6. Academic OneFile, proxy.buffalostate.edu:2101/ps/i.do?p=AONE&sw=w&u=buffalostate&v=2.1&it=r&id=GALE%7CA98469846&sid=summon&asid=6ad973607b0bc6a4612884606538a51b. Accessed 11 July 2017.

"Copper - Element information, properties and uses | Periodic Table." *Royal Society of Chemistry - Advancing excellence in the chemical sciences*. Royal Society of Chemistry, 2017. Web. 02 July 2017.

"Core Documents." *American Alliance of Museums*, Web. 21 June 2018.

"Discover Industrial Hygiene," *AIHA: Protecting Worker Health*. American Industrial Hygiene Association. 2018. Web. Feb, 2018.

“Health & Safety Labeling, and Other Chemical Hazard Management Issues in the Arts.” *Health & safety labeling, and other chemical hazard management issues in the arts*. Hamilton College, n.d. web. 30 Nov. 2016

"Home." *ACMI: The Arts and Creative Materials Institute, Inc.* Quacito LLc., 2017. Web. 15 July 2017.

“How to Select Gloves: An Overview for Collections Staff.” *Conserve O Gram*, The National Park Service, Web. Sept. 2010. No. 1/12.

"Lead." *Encyclopedia Britannica*. Comp. The Editors of Encyclopedia Britannica. Encyclopedia Britannica Inc., 23 Aug. 2013. Web. 15 Apr. 2017.

"Mercury - Element information, properties and uses | Periodic Table." *Royal Society of Chemistry - Advancing excellence in the chemical sciences*. Royal Society of Chemistry, 2017. Web. 02 July 2017.

"Occupational Safety and Health Act (OSHA) of 1970." *SHRM*. Society for Human Resource Management, 07 Oct. 2008. Web. 5 July 2017.