PROJECT REPORT

Chemistry in the Museum:
Elucidation of 1920s Medical Kits

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Abstract
This project report describes the process of a team of undergraduate researchers (Chemistry and Nursing majors), who analyzed 20th-century medical kits housed at The Columbus Museum (Columbus, GA, USA). Curators and museum personnel were unfamiliar with the contents and needed assistance in identifying the various chemical contents. Items were identified by the Taylor Lab, which was followed by fully elucidating the chemical information in a chemical report and student-curated exhibit. The intent of this project was to help the museum be aware of how to properly curate and store the medical collections for an extended period. Laboratory analyses were executed to determine the composition of the aged items in the collections. The historical context of these kits and their contents provided knowledge of medicine to the community of Columbus, Georgia, in addition to explaining the use of medically related items in the 20th century.

Introduction
Can chemists, nurses, and historians work together? At the request of The Columbus Museum (Columbus, GA), Chemistry professor Kerri Shelton Taylor and students Shyrisse Ramos (Chemistry) and Jordan Spires (Nursing) of Columbus State University (CSU) were asked to investigate two collections consisting of three 20th-century medical kits for the purpose of identifying the various chemical contents. One of the kits was composed primarily of medicines, which were contained in the form of ampoules and hypodermic needles, alongside a select few hypodermic tablets. The other kits contained

instruments for the use of administering medicines and assisting patients in the 20th century. It was assumed that these kits were used to assist with house calls for patients of all ages.

Three medical kits from the early 20th century are housed in The Columbus Museum. Collection 89.23.2 is characterized as a nurse's kit with related contents, belonging to Mrs. Sarah Yarbrough Allen. Collections 89.23.1 and 95.19.0 are characterized as physicians' kits. The contents of 95.19.0, acquired in 1995, were owned by Dr. John L. Hilt. The contents of 89.23.1 belonged to Dr. Clarence C. Allen. Upon review of the contents in the nurse's and physicians' bags, it seemed likely that these medical professionals completed house calls. These three individuals, Dr. John L. Hilt, Dr. Clarence C. Allen and Mrs. Sarah Yarbrough Allen, were probably general practitioners in the Columbus, Georgia area.

These kits contained the typical medicines used during the 20th century to cure/treat the most common ailments, such as colds, syphilis, and cardiac arrest. The hypodermic needles and the ampoules were kept in a pocket-size case, and the kits also contained medicines that could cure a range of different ailments. There were also tools we found in these kits, such as examples of early blood transfusion apparatus and speculum.

Methods

The purpose of this project was to chemically analyze the medicines used by these medical professionals during the early 20th century. A secondary goal of this project was to aid the museum specialists and the collections manager in the determination of the stability and safety of the chemical contents. The Columbus Museum aimed to preserve the integrity of these collections and maintain them for years to come. The chemical analysis of these contents intended to show the conditions for proper storage and preservation of the items over extended periods of time.

When executing this project and understanding the real-world problem of chemical analysis outside a classroom setting, the CSU scientists viewed the issue as subject matter experts. In retrospect, it would have been helpful to consider the methods used by medically related museums. Expert agencies like the National Park Service (NPS) would have provided great guidance on this topic. NPS requires:

- Safe and secure storage of museum collections in a dedicated space with minimal penetration and optimum thermal performance.
- Museum storage space adequate to accommodate the particular characteristics and quantity of objects, specimens, and archival items in the collection. It must also provide adequate space to accommodate reasonable growth of the collection over the next ten years.
- Organization of the space to allow for the efficient use of curatorial equipment and techniques and to provide for effective access and optimum preservation of the museum collection.
- Containerizing collections to the extent possible to minimize the negative effects of relative humidity and temperature fluctuations.
- Insulating the space so it will maintain a stable environment that protects the objects from adverse temperature and relative humidity conditions and damage from biological infestations (National Park Service, 2000).

According to the Building Design and Construction Network, museums, archives, and art storage facilities generally have strict requirements for interior temperature and relative humidity (RH) control. The unofficial museum standard for temperature and RH is 70°F and 50% (O'Brien, 2010).

The process of investigating this "real-world" problem was fully designed and executed by the CSU team and occurred in four phases (Table 1). Phases 1–3 were typical for Chemistry and Nursing research students. In Phase 1, the students itemized the collection and deduced which chemicals needed to be regenerated (Figure 1). The authors chemically regenerated the aged compounds to minimize destructive analysis of the museum components (Figures 2–3). The method for assessing the hazards was chosen by the research students, under the mentorship of the professor, museum curator, and collections manager.

TABLE 1. Four-Phase Process Associated with Cataloging and Curating the 20th-Century Medical Kits with Timeline of Executed Dates

July 2019	August–December 2019	March 2020	June 2020–January 2021
PHASE 1	**PHASE 2**	**PHASE 3**	**PHASE 4**
•Review museum collections • Record aged items through photography •Deduce items needed for regeneration in lab • Order necessary reagents	• Regenerate aged compounds collections in order to understand concerns of hazards • Determine hazards of aged compounds • Compile data into report	• Continue to arrange chemical information in scientific report • Continue analysis	• Present chemical information in scientific report • Collaborate with Columbus Museum to curate and install exhibition based on the project analysis • Write explanatory text for general audiences in a museum setting

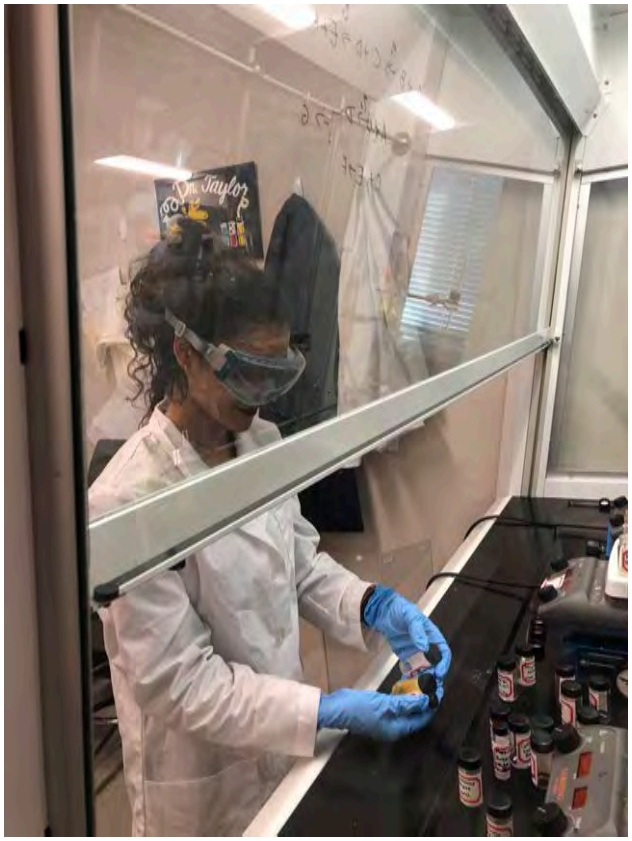
FIGURE 1. Shyrisse Ramos catalogs the age and identification of the aged items in the 20th-century medical kits, housed at The Columbus Museum.

FIGURE 2. Jordan Spires replicates the chemical compounds that would serve as a representation of aged items in the 20th-century medical kits housed at The Columbus Museum.

TABLE 2. Samples Exposed to Distilled Water

ITEM	OBSERVATIONS				
	DAY 1 (10/04/19)	DAY 5 (10/08/19)	DAY 6 (10/09/19)	DAY 7 (10/10/19)	DAY 60 (12/02/19)
Ferrous sulfate	Slight bluish, clear liquid	No change	Slight change in color	Yellow liquid	No change

FIGURE 3. Shyrisse Ramos catalogs the age and identification of the aged items in the 20th-century medical kits, housed at The Columbus Museum.



In Phase 2, four variables were tested: (1) temperature, (2) ambient air/moisture, (3) water sensitivity, and (4) light. Four vials of each chemical were prepared and labeled according to the variable being tested. The ambient temperature of the lab was routinely monitored at 67 °F. However, the change in temperature of the regenerated contents was studied from 32–158 °F. This range of temperature was chosen to represent the exposure of the contents to extreme cold (A/C overload) or heat (loss of A/C). Table 2 shows examples of compounds tested for water solubility. An interesting finding of Phase 2 was related to ferrous sulfate, which displayed an extreme color change from bluish solution to yellowish solution when exposed to moisture and ambient air during the two-month period (Figure 4).

Phase 4 was an opportunity for the students to develop their roles as scientific specialists. The curation and installation involved strong collaborations among the Taylor Lab, museum curator, and collections manager.

Chemical Findings

A chemical report (which can be found in the appendix) was provided to the museum to demonstrate the context and comparison of how medicines were used in the 20th century compared to the present day (21st century).

FIGURE 4. Water sensitivity of ferrous sulfate is measured. Distilled water (0.5 mL) was added to ferrous sulfate (0.1 g).

FIGURE 5. Chemical structures of medicines in the medical kits housed at The Columbus Museum

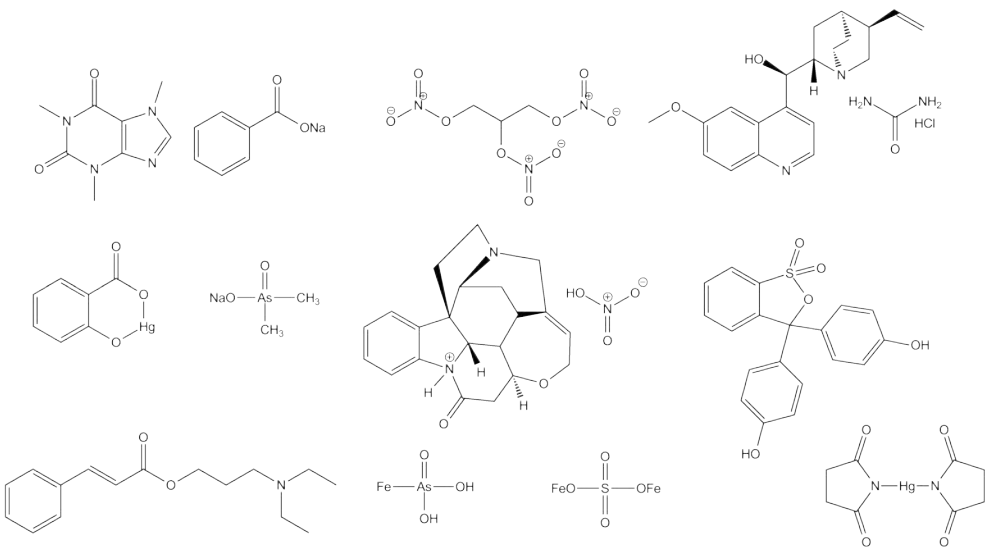


TABLE 3. Chemical Contents Characterized by Their Use in the 20th and 21st Centuries

Chemical	20th-Century Use	Present-Day Use
Mercury Succinimide (Hypodermic Tablets)	Treatment of gonorrhea; pulmonary tuberculosis	No longer used because of its toxicity
Quinine & Urea Hydrochloride	Local anesthesia, used to numb a specific part of the body. Quinine was also used to treat malaria.	Often used for abdominal surgeries; it is still used today for the treatment of some painful
Mercuric Salicylate (with Quinine and Urea Hydrochloride)	Mercury was used as a laxative and dewormer; also used as a syphilitic remedy	N/A Highly toxic
Quinine Dihydrochloride	Treatment of malaria	To treat malaria
Sodium Cacodylate	Treatment of syphilis	Highly toxic, since it is an arsenical compound; today considered a human carcinogen and used as a herbicide.
Strychnine Nitrate	As an analeptic, a central nervous system stimulant; also used in treatment of non-ketotic hyperglycinemia*	Often used as a rat poison; pesticide
Iron Arsenite & Strychnine	Arsenic was used as a synthetic chemotherapeutic agent and as a syphilis treatment, specifically in a compound	Used today in the manufacturing of insecticides
Phenolsulphthalein (Phenol Red)	Laxative, also used as a renal test to test for kidney failure; injected intravenously	Today used as a pH indicator; may cause cancer in humans
Mulford Hypo-Unit (Hypodermatic Injections)	Used to store hypodermic needles, made of nickel	N/A
Atropine Sulfate	To inhibit salivary and bronchial secretions, for cardiopulmonary resuscitation, management of acute myocardial infarctions (heart attacks)	Used to treat low heart rate; antimuscarinic agent; reduce salivation and bronchial secretions before surgery; antidote for
Digitol Aqueous	For cardiac disease	Unknown
Strychnine	Increases reflexes. When heated, emits highly toxic fumes. Remedy for heart and respiratory complaints, acts as a stimulant	Rat poison
Nitroglycerin	To prevent chest pain (agina) in patients with heart conditions, hypertension	To prevent chest pain (angina)
Camphor in Oil	Relieves pain, irritation, itching (natural oil)	Creams, ointments, and lotions
Caffeine Benzoate (Caffeine Sodium Benzoate)	Stimulates heart and breathing, wanted to counteract diminished blood pressure/respiration during anesthesia (for low blood pressure)	Treatment for respiratory depression (hypoventilation), but is not approved by the FDA
Cardiac ((R)-(-)-Phenylephrine Hydrochloride)	Anti-inflammatory, cold medicine, decongestant	Anti-inflammatory, cold medicine, decongestant
Aposthesine	Anesthesia	Not used because of its toxicity
Ribothiron, made of ferrous sulfate with vitamin B2, thiamine hydrochloride, and riboflavin	Iron deficiency anemia	N/A

Additionally, the report described the results of the laboratory analysis when the contents were tested against the variables of temperature, ambient air, water sensitivity, and light. Example compounds studied are shown in Figure 5. At the museum's request, necessary reagents were ordered and mimicked to replicate the compounds of the aged medical collections in order to determine hazards.

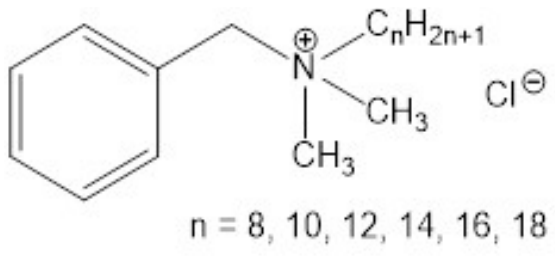
Table 3 displays the chemicals itemized by the CSU team. Interesting findings included the use of several medicines containing mercury, which is no longer used in the 21st century. Similarly, strychnine was used as a stimulant for the cardiac and nervous systems, while in the present day it is used as a rat poison. Thirdly, arsenic was noted in iron arsenite, in medicines used as a synthetic chemotherapeutic agent and as a syphilis treatment; arsphenamine is now used as an insecticide. However, it was exciting to realize that some medicines have been consistently used across both centuries. The chemicals camphor, caffeine benzoate, and (R)-(-)-phenylephrine hydrochloride have been used for the relief of pain, respiratory/cardiac, and inflammatory issues, respectively.

Lygel Tube and Bloody Gauze

The major goal of this study and the subsequent student exhibit was to understand two unique and interesting contents: a rusting Lygel ointment (95.19.47 D) and brittle gauze with dried blood spots (95.19.56 O-P). Samples from these contents were taken and submitted for external analysis to the Mass Spectrometry Lab at Auburn University. Multiple samples were collected by generic q-tips to analyze and compare a native (non-rust) sample to a rusted sample of the Lygel tube.

The swabbed ends of 95.19.56 D (rust and native samples), along with a blank q-tip, were submitted for analysis. All q-tip samples were cut off with a clean scalpel, and 300 µL of hexanes and 300 µL 50% water 50% methanol were added. Samples were vortexed and sonicated well. The liquid was centrifuged to separate the layers and the hexanes was analyzed by GC-MS, while aqueous was analyzed by LC-MS in positive and negative modes after separation on a Waters BEH C18 column. Select organic compounds were identified in the non-rust and rust samples. In the rust sample, decamethylcyclopentasiloxane, dodecamethylcyclohexasiloxane, and tetradecamethylcycloheptasiloxane were noted while in the non-rust sample, diethyl phthalate and undecane were detected. All structures can be viewed in the appendix.

FIGURE 6. Schematic representation of benzalkonium chloride



Lysol was used as an antiseptic jelly meant to prevent the growth of disease-causing microorganisms. The directions were still visible on the rusted tube and state that this jelly was used with a douche to help clean the reproductive area of female patients. In the directions, there is mention of Lysol. The benzene ring in the Lysol was also present in the diethyl phthalate in the non-rusted lygel sample. The main active ingredient in Lysol was benzalkonium chloride (Figure 6).

According to a HuffPost article, Lysol was used in the 1920s for feminine hygiene issues and odors. This product was used as an aid to spice up a couple's "love life behind closed doors." An example of these 20th-century ads, which were meant to encourage women to wash routinely (Bologna, 2018), can be found on the HuffPost website. In the 21st century, however, Lysol is known to be used as a disinfectant to protect from harmful germs on a variety of surfaces.

Samples of the brittle gauze and the dried blood spots (95.19.56 O-P) were taken and submitted for external analysis at the Auburn University Mass Spectrometry Lab. Chromatograms were provided in a supplementary document to the Columbus Museum as pdf files. Excel files (csv) from the Auburn University Mass Spectrometry Lab contained both positive and negative ions. This data provided the peak height and area for the ions at the different retention times to help the Taylor Group probe the human metabolome database (hmdb.ca) to find tentative identities. Upon review, more than 3,900 items were quantified and identified by the human metabolome database (hmdb.ca).

Limitations with the blood analysis include further analysis to determine the background and potential recipient(s) of the blood samples located on the soiled

gauze. Initial discussions were completed with a forensic chemist at the Georgia Bureau of Investigations (GBI), Mrs. Victoria Oehrlein, to distinguish a method and company for testing the blood sample. However, the experts noted some possible complications with DNA analysis: (1) separation of extraneous DNA and (2) financial cost.

Factor 1: Extraneous DNA

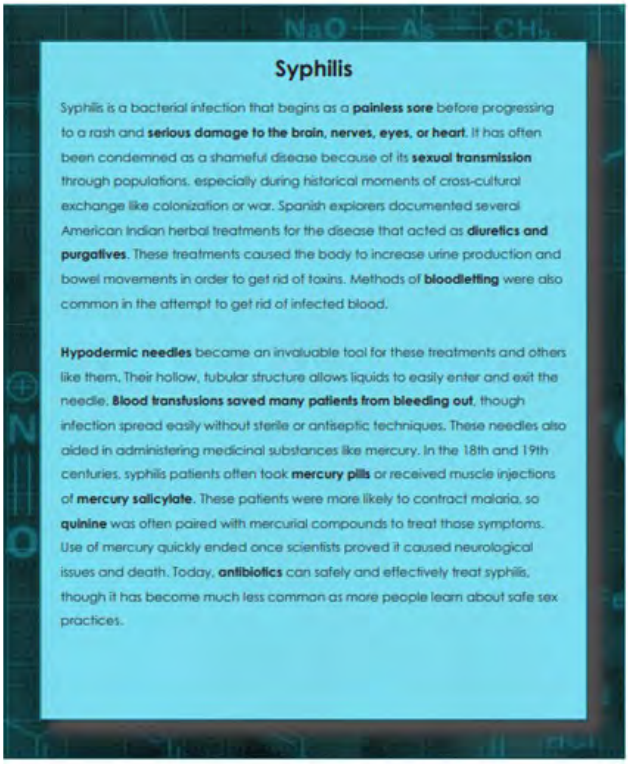
The blood samples, item 95.19.56 O-P, are from the 20th century (1920s–1940s) and likely have encountered a number of clinical professionals, patients, family descendants, museum personnel, scientists….to name only a few. This complicates analysis, as we would not know whose DNA truly belongs to the blood stain. Throughout the investigative process, the museum personnel and Taylor Group always wore gloves and made sure to maintain the composition of the items. In a forensic lab setting, DNA samples are compared against a known roster of individuals to decipher the true candidate. In this case, there are too many "knowns" to account for in this 100-year gap between the gauze being soiled and the present analysis.

The interest in the blood samples was piqued by the desire to understand the details associated with the dried blood. Blood can have many descriptors, such as gender, age, type, etc. These three kits were used by three different clinicians with the intention of serving the community of Columbus, Georgia as general practitioners. This means that the blood samples could be from patients of any age (i.e., baby, child, or adult) or gender (female or male). Furthermore, these blood samples could have easily been contributed by more than one source and could in fact be from multiple patients or the clinicians themselves. The commercial labs mentioned that the samples were, to date, considered ancient, which meant that they likely would not withstand the analysis. The Taylor Group would not be confident in reporting our findings to the museum.

Factor 2: Financial Cost

During multiple discussions with commercial labs, it became clear that the analysis would cost $2,000–3,000 at a minimum. Our budget did not allow for such an expenditure. The associated cost was not something that the Taylor Group or The Columbus Museum considered essential, which led to the end of the inquiry.

FIGURE 7. *Mystery Science* panel on syphilis, written collaboratively by Ramos and Spires with the collections manager and museum curator



Results and Reflection

Data was presented in a poster presentation at a regional chemistry conference, the Southeastern Regional Meeting of American Chemical Society (SERMACS), in October 2019. The chemical report was submitted to Columbus Museum staff Rebecca Bush and Aimee Brooks in December 2019. In addition to the report and poster, the students contributed a final reflection on this project. The exhibition installation began in April 2020; however, the original dates were shifted due to COVID. The team worked remotely and safely amidst the pandemic to generate *the Mystery Science Museum 3000*. The exhibition was open to the public from July 2020 until January 2021. Ramos and Spires collaborated with the museum collections manager and history curator on the writing of explanatory text for general audiences in a museum setting. The major topics that were spotlighted in the exhibition included tuberculosis, anesthesia, and syphilis (Figure 7).

This museum exhibition elicited strong civic engagement, as it was created by CSU students and demonstrated the connection of the 20th-century kits of

previous Columbus residents and clinicians who served the Columbus community. The team of Ramos and Spires was awarded the Georgia Association of Museums Student Project Award (Figure 8).

FIGURE 8. Spires and Ramos received the Georgia Association of Museums Student Project Award for their work on the exhibition Mystery Science Museum 3000. Rebecca Bush (left) was the primary staff liaison for the project and Holly Beasley Wait (right) is a GAM Awards committee member and executive director of the National Civil War Naval Museum in Columbus.

Reflections

Mentor

I was amazed at how the medical uses of the various items evolved from the 20th century to the present day. It was eye-opening to learn that caustic materials can be used/viewed as beneficial for the body (i.e., quinine and strychnine). One of the most interesting medicines was a rusting tube that was called Lygel. In the 20th century, it was used for female hygiene to help intimacy in the bedroom. However, the components of Lygel are used in the present day as Lysol. It is unsettling to know that such a material that today is used for cleaning counters was perceived as useful according to the field of gynecology.

As a mentor, I am thrilled for the opportunity to learn alongside my students and further understand the historians' creed: everything has a history. As a scientist, I appreciate the value of medicine's evolution. Medical care and curative materials are necessary and adapted according to the needs of society. This project has truly been an illuminating experience. Lastly, this research opportunity has helped me to reflect on my experiences as a patron in the museum setting. I have become aware of the sense of pride, and at times even humor, that curators can have in their job. More specifically, I have gained an appreciation of the elements needed to generate a well-established exhibit (Midden, 2018).

When creating an exhibit, an interpretive master plan needs established, which includes a four-step process: (1) concept design, (2) schematic design, (3) design development, and (4) final design (Smithsonian Museums, 2018). Within this arrangement, the curator must present a big idea using key messages and critical questions. The students did a phenomenal job helping to arrange the exhibit. Both the students collaboratively wrote the panels of text for the exhibit, alongside the curators at The Columbus Museum. I was especially impressed by the subtleties in the exhibit. The major color that spanned the exhibition was the blue color traditionally found on operating gloves and the structures of the chemical components in the three medical kits were spread along the walls of the exhibition.

Students' responses

This project was very informative. We have learned about the various medicines that were used in the 20th century, in comparison to medicines that are used today. It was truly an honor to be able to analyze the components of these chemicals and observe the evolution of medicine since the 1920s. Many of the medicines used have adverse effects and are no longer used in practice. The impact of the doctor/nurse on the patient is demonstrated through the instruments and cases (Jarman, 2015; National Research Council, 2011).

Through the process of working with The Columbus Museum, we have been able to witness the extensive process of museum curation and exhibition. It is no easy task, but it is a service to the community (Bachofer & Cass, 2022). This project not only incorporates history and art, but also shows the role of science in historical contexts.

Some medicines that were used during the 20th century are not used today because of potential hazards. During that time period, the hazards were not known; however, they have been documented in recent years through scientific advancements. Because of the age of the chemicals and medicines that are currently possessed by The Columbus Museum, special care must be taken so that these pieces of

history can be maintained for years to come. Our research chronicles all observed changes as a result of each chemical modification.

Civic Engagement

The collaborative project of the CSU team and The Columbus Museum strongly supports the goal of civic engagement. The Association of American Colleges & Universities defines the concept of civic engagement as "working to make a difference in the civic life of our communities and developing the combination of knowledge, skills, values, and motivation to make that difference. It means promoting the quality of life in a community, through both political and non-political processes." (Ehrlich, 2000) The students were provided opportunities outside the classroom to engage with the museum staff and university faculty in the regional area of southwest Georgia and parts of Auburn, Alabama. The goal of civic engagement was achieved. CSU students participated in unique curatorial and science activities of personal and public concern that were both individually life enriching and socially beneficial to the Columbus community. In short, the students supported The Columbus Museum in its ultimate mission to preserve history for future generations.

FIGURE 9. Response from a CHEM 1152 student

I have lived in the Columbus area for the last 3 years and never have been to the Columbus museum. I found it quiet fun to see the history of how Columbus was discovered and how it has grown over time. It was also a great distraction from studying for exams. I think that the most interesting part for me throughout the Nursing exhibit was how medical physicians used to carry around small medical kit full which contained prefilled hypodermic needles which contained the medicine helpful to decrease and treat a heart attack. I was actually shocked how many common molecules that I have learned in class are actually used in the medical field. I would have never really thought of how aspirin is actually created, just how it is used to help pain, inflammation and fever reducer. My overall experience of the exhibit showed a better understanding of how important science, especially chemistry is for everyday life.

The exhibit showed the connection between medicine and chemistry during the 1920-40s. While also showing how much chemistry has changed over time to improve medicine for problems related to current everyday life. Advanced studying of medicine has determined the good and the bad of early used medicine and has only generated a greater opportunity for better modern-day medicine and will continue to construct new and improved medicine in the medical field. It has also showed that some chemicals that were used back in the early 1900's could also cause later consequences. An example would be Apothesine which was used for tuberculosis treatment and anesthesia, however today it is not used because it is considered to be toxic.

This interdisciplinary project and student-focused exhibit served as a great example of civic engagement. This student exhibition very effectively supported the medical theme rooted in subsequent exhibitions and museum programming. *Mystery Science Museum 3000* followed an exhibition, "The Doctor Is In," which spotlighted the history of healthcare in Columbus, Georgia (Columbus Museum, 2020). The unique feature of the *Mystery Science Museum 3000* exhibit specifically spotlighted Columbus natives as successful servant leaders in the field of medicine. Furthermore, the exhibition was pivotal in publicly demonstrating the items used by Sarah Yarbrough Allen, Columbus's first African American registered nurse.

This project was an opportunity for CSU undergraduate students and local professionals to collaborate on an impactful creative endeavor for the city of Columbus, Georgia. CSU students served as servant leaders by honoring the community. In addition, the students' research provided context on how certain chemicals were used to treat medical conditions in the previous century. As such, the research team provided museum staff with knowledge on the precautions associated with safely maintaining the chemical items and handling historic medical kits.

Even though the exhibition was presented during the pandemic, efforts were made to publicize the content. Allied health majors from a CHEM 1152 course were provided bonus points for attendance at the exhibition. In Figure 9, a student comments about how the course impacted her educational focus. The general comments show that attendees found satisfaction in seeing chemistry in practice rather than in theory. Some mentioned that the exhibit was a good reminder to keep pushing through the rough parts of school, due to the satisfaction and value of being a practicing clinician. Students also commented that the researchers did a great job designing the exhibit, as the content was put in terms simple enough for the general audience to understand while also being able to enjoy the experience.

This project impacted the research students in unique ways as it related to their future vocations. It further enforced Shyrisse's desire to be a medical examiner and Jordan's

plan to become a nurse anesthetist. This project has continually fascinated the students, due to their eclectic interests in chemistry, medicine, and art. They contributed their work and knowledge through the historical view of the items in these collections.

On a grander scale, this exhibition impacted the community and medicine. These students' collaboration displayed how medicine has evolved since the 20th century, as well as within the context of Columbus, Georgia. It demonstrated how intertwined the disciplines of science, art, and history can truly become. Furthermore, the community of Columbus, Georgia witnessed the influence and contribution of two passionate and hardworking students from Columbus State University.

Final Thoughts

Ultimately, the purpose of this project was twofold: to provide students from two very different disciplines with the experience of showing the importance and value of the other discipline, while also serving the practical purpose of helping The Columbus Museum further understand the materials in their collection and how they should continue to preserve these materials.

Following the exhibition, the Collections Manager commented that museums do have tight standards regarding environmental requirements. However, some in the field (including conservators) believe that those requirements could be safely "loosened" in certain situations, locations and collections. For example, it can be really hard for southeastern museums to maintain a 50% RH during the humid summer. It can be really hard for southwestern museums to reach it in their dry summers. If it can be proven that materials can be safely cared for at relative humidity levels besides the standard 50%, that could give museums an economic benefit by redirecting resources into other things like educational programming. It's also a greener choice, which is good for everyone. Furthermore, this loosening of requirements could allow the smaller museums more opportunities to borrow art and artifacts from larger museums, expanding audiences that might not normally get a chance to see those objects. Overall, the museum industry still needs to be convinced that this is a safe thing to do, and any project adding to that knowledge base, for or against, is beneficial.

In this process, the research team in the Taylor Group learned from the expertise of the curatorial team at The Columbus Museum. The research team provided insight about the handling and preserving of chemical materials in the collection, which was previously limited. These findings have allowed the museum to provide more detail for their in-house content management system, and it also provided an opportunity to display this material as a part of a medical exhibit.

About the Author

Kerri Taylor is an associate professor at Columbus State University (Columbus, GA, USA), and her academic and research focus is on organic chemistry, specifically the field of synthetic medicinal chemistry and material science. Taylor holds a Bachelor of Arts degree in chemistry from Miami (Ohio) University, a master of science degree in chemistry from the University of Kentucky, and a Ph.D. in chemistry from the University of Akron.

Acknowledgements

I would like to thank and acknowledge Columbus State University for allowing me to mentor and guide the students on this project. The Columbus Museum (Columbus, GA) should also be acknowledged and thanked for their permission to review the contents of the 20th-century kits. Funding was provided by CSU's Department of Chemistry, the CSU Interdisciplinary Initiative Grant (provided by the CSU Faculty Center), and the CSU Student Research and Creative Endeavors Grants Committee.

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APPENDIX:
Chemistry in the Museum Elucidation of 1920s Medical Kits

Chemical Report

This section of the report contains chemical analysis, examination results, and suggested recommendations for short-term and long-term use.

List of Tables

List of Figures

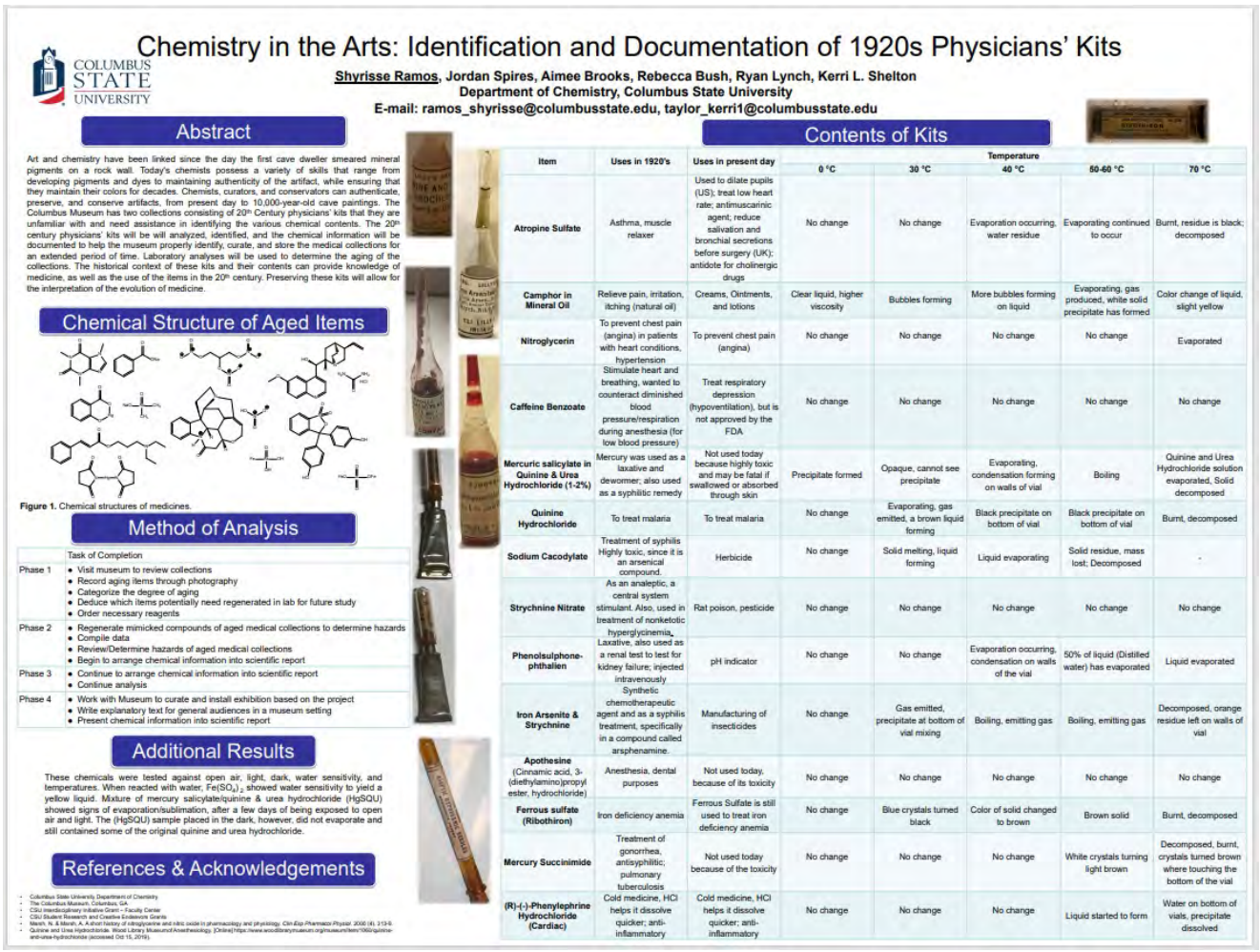
Background

Three medical kits from the early 20th century are housed at The Columbus Museum. Collection 89.23.2 is characterized as a nurse's kit and related contents, belonging to Mrs. Sarah Yarbrough Allen. Collections 89.23.1 and 95.19.0 are characterized as physicians' kits. The contents of 95.19.0, acquired in 1995, were owned by Dr. John L. Hilt. The contents of 89.23.1 belonged to Dr. Clarence C. Allen. Due to the contents within the nurse's and physicians' bags, it seemed likely that these medical professionals completed house calls. These three individuals, Dr. John L. Hilt, Dr. Clarence C. Allen, and Mrs. Sarah Yarbrough Allen, were probably general practitioners.

These kits contained the typical medicines used during the 20th century to cure/treat the most common ailments, such as colds, syphilis, and cardiac arrest. The hypodermic needles and the ampoules were kept in a pocket-size case, and the kits also contained medicines that could cure a range of different ailments. There were also tools in these kits, such as an early blood transfusion apparatus and a speculum, which suggests that these doctors made house calls and carried the necessary items for various situations that could arise.

The purpose of this project was to chemically analyze the medicines used by these medical professionals during the early 20th century. A secondary goal of this project was to aid the museum specialists and the collections manager in the determination of the stability and safety of the chemical contents. The Columbus Museum aims to preserve the integrity of these collections and maintain them for years to come. The chemical analysis of these contents intended to show the conditions for proper storage and preservation of the items over extended periods of time. Table 1 demonstrates the context and comparison of how medicines were used in the 20th century compared to the present day (21st century). Tables 2–5 describe the results of the laboratory analysis, when the contents were tested against the variables of temperature, ambient air, water sensitivity, and light.

FIGURE 10. Poster presented at SERMACs conference



Chemistry in the Arts: Identification and Documentation of 1920s Physicians' Kits

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Abstract

Art and chemistry have been linked since the day the first cave dweller smeared mineral pigments on a rock wall. Today's chemists possess a variety of skills that range from developing pigments and dyes to maintaining authenticity of the artifact, while ensuring that they maintain their colors for decades. Chemists, curators, and conservators can authenticate, preserve, and conserve artifacts, from present day to 10,000-year-old cave paintings. The Columbus Museum has two collections consisting of 20th Century physicians' kits that they are unfamiliar with and need assistance in identifying the various chemical contents. The 20th century physicians' kits will be will analyzed, identified, and the chemical information will be documented to help the museum properly identify, curate, and store the medical collections for an extended period of time. Laboratory analyses will be used to determine the aging of the collections. The historical context of these kits and their contents can provide knowledge of medicine, as well as the use of the items in the 20th century. Preserving these kits will allow for the interpretation of the evolution of medicine.

Chemical Structure of Aged Items

Figure 1. Chemical structures of medicines.

Method of Analysis

	Task of Completion
Phase 1	• Visit museum to review collections • Record aging items through photography • Categorize the degree of aging • Deduce which items potentially need regenerated in lab for future study • Order necessary reagents
Phase 2	• Regenerate mimicked compounds of aged medical collections to determine hazards • Compile data • Review/Determine hazards of aged medical collections • Begin to arrange chemical information into scientific report
Phase 3	• Continue to arrange chemical information into scientific report • Continue analysis
Phase 4	• Work with Museum to curate and install exhibition based on the project • Write explanatory text for general audiences in a museum setting • Present chemical information into scientific report

Additional Results

These chemicals were tested against open air, light, dark, water sensitivity, and temperatures. When reacted with water, $Fe(SO_4)_2$ showed water sensitivity to yield a yellow liquid. Mixture of mercury salicylate/quinine & urea hydrochloride (HgSQU) showed signs of evaporation/sublimation, after a few days of being exposed to open air and light. The (HgSQU) sample placed in the dark, however, did not evaporate and still contained some of the original quinine and urea hydrochloride.

References & Acknowledgements

- Columbus State University Department of Chemistry
- The Columbus Museum, Columbus, GA
- CSU Interdisciplinary Initiative Grant – Faculty Center
- CSU Student Research and Creative Endeavors Grants
- Marsh, N. & Marsh, A. A short history of nitroglycerine and nitric oxide in pharmacology and physiology. *Clin Exp Pharmacol Physiol.* 2000 (4). 313-9.
- Quinine and Urea Hydrochloride. Wood Library Museum of Anesthesiology. [Online] https://www.woodlibrarymuseum.org/museum/item/1060-quinine-and-urea-hydrochloride (accessed Oct 15, 2019).

Contents of Kits

Item	Uses in 1920's	Uses in present day	Temperature				
			0 °C	30 °C	40 °C	50-60 °C	70 °C
Atropine Sulfate	Asthma, muscle relaxer	Used to dilate pupils (US); treat low heart rate; antimuscarinic agent; reduce salivation and bronchial secretions before surgery (UK); antidote for cholinergic drugs	No change	No change	Evaporation occurring, water residue	Evaporating continued to occur	Burnt, residue is black; decomposed
Camphor in Mineral Oil	Relieve pain, irritation, itching (natural oil)	Creams, Ointments, and lotions	Clear liquid, higher viscosity	Bubbles forming	More bubbles forming on liquid	Evaporating, gas produced, white solid precipitate has formed	Color change of liquid, slight yellow
Nitroglycerin	To prevent chest pain (angina) in patients with heart conditions, hypertension	To prevent chest pain (angina)	No change	No change	No change	No change	Evaporated
Caffeine Benzoate	Stimulate heart and breathing, wanted to counteract diminished blood pressure/respiration during anesthesia (for low blood pressure)	Treat respiratory depression (hypoventilation), but is not approved by the FDA	No change	No change	No change	No change	No change
Mercuric salicylate in Quinine & Urea Hydrochloride (1-2%)	Mercury was used as a laxative and dewormer; also used as a syphilitic remedy	Not used today because highly toxic and may be fatal if swallowed or absorbed through skin	Precipitate formed	Opaque, cannot see precipitate	Evaporating, condensation forming on walls of vial	Boiling	Quinine and Urea Hydrochloride solution evaporated, Solid decomposed
Quinine Hydrochloride	To treat malaria	To treat malaria	No change	Evaporating, gas emitted, a brown liquid forming	Black precipitate on bottom of vial	Black precipitate on bottom of vial	Burnt, decomposed
Sodium Cacodylate	Treatment of syphilis Highly toxic, since it is an arsenical compound.	Herbicide	No change	Solid melting, liquid forming	Liquid evaporating	Solid residue, mass lost; Decomposed	-
Strychnine Nitrate	As an analeptic, a central system stimulant. Also, used in treatment of nonketotic hyperglycinemia.	Rat poison, pesticide	No change	No change	No change	No change	No change
Phenolsulphone-phthalien	Laxative, also used as a renal test to test for kidney failure; injected intravenously	pH indicator	No change	No change	Evaporation occurring, condensation on walls of the vial	50% of liquid (Distilled water) has evaporated	Liquid evaporated
Iron Arsenite & Strychnine	Synthetic chemotherapeutic agent and as a syphilis treatment, specifically in a compound called arsphenamine.	Manufacturing of insecticides	No change	Gas emitted, precipitate at bottom of vial mixing	Boiling, emitting gas	Boiling, emitting gas	Decomposed, orange residue left on walls of vial
Apothesine (Cinnamic acid, 3-(diethylamino)propyl ester, hydrochloride)	Anesthesia, dental purposes	Not used today, because of its toxicity	No change	No change	No change	No change	No change
Ferrous sulfate (Ribothiron)	Iron deficiency anemia	Ferrous Sulfate is still used to treat iron deficiency anemia	No change	Blue crystals turned black	Color of solid changed to brown	Brown solid	Burnt, decomposed
Mercury Succinimide	Treatment of gonorrhea, antisyphilitic; pulmonary tuberculosis	Not used today because of the toxicity	No change	No change	No change	White crystals turning light brown	Decomposed, burnt, crystals turned brown where touching the bottom of the vial
(R)-(-)-Phenylephrine Hydrochloride (Cardiac)	Cold medicine, HCl helps it dissolve quicker; anti-inflammatory	Cold medicine, HCl helps it dissolve quicker; anti-inflammatory	No change	No change	No change	Liquid started to form	Water on bottom of vials, precipitate dissolved

TABLE 4: Museum Contents Characterized by Their Use in the 20th and 21st Centuries, Recommended Dosage and Side Effects (Any words that appear unique will be denoted with an asterisk (*) and described in the "Key Words & Definitions" section.)

Contents

Table 1 categorizes the chemicals in the collections of 89.23.1, 95.19.0, and 95.19.1. The contents are ordered in numerical order. Each compound is characterized by its use in the 20th and 21st centuries, recommended dosage, and side effects (safety concerns).

Museum Coding	Item	20th-Century Use	Present-Day Use	Dosage	Safety Concerns/
1995.19.27 C	Mercury Succinimide (Hypodermic Tablets)	Treatment of gonorrhea; pulmonary tuberculosis	Not used because of its toxicity		Side Effects
1995.19.56 A–B	Transfusion apparatus; the metal ends are where the interchangeable needles are connected. The orange tube without the metal on its ends is the tourniquet.	Used for blood transfusions	Modified transfusion apparatus; intravenous lines are inserted into the blood vessel. Blood type is matched with patient's blood type	N/A	Poisonous; stable in air, literature says it can be affected by light
1995.19.57 B	Quinine & Urea Hydrochloride	Local anesthesia, used to numb a specific part of the body; Quinine was also used to treat malaria.	Often used for abdominal surgeries; it is still used today for the treatment of some painful conditions.	Administered through an intravenous injection.	N/A
1995.19.57 C (also coded as 1995.19.57 E)	Mercuric Salicylate (with Quinine and Urea Hydrochloride)	Mercury was used as a laxative and dewormer; also used as a syphilitic remedy.	N/A Highly toxic	Was mixed with water for internal use, mixed with olive oil for hypodermic use (injection), and mixed with Quinine and Urea Hydrochloride (ampoules)	N/A
1995.19.57 D	Quinine Dihydrochloride	Treatment of malaria	Treatment of malaria	Intravenous injection	Toxic by inhalation and ingestion
1995.19.57 F	Sodium Cacodylate	Treatment of syphilis;highly toxic, since it is an arsenical compound	Today considered a human carcinogen and used as a herbicide	Unknown	N/A
1995.19.57 G	Strychnine Nitrate	As an analeptic, a central nervous system stimulant; also used in treatment of non-ketotic hyperglycinemia*	Often used as a rat poison; pesticide	Unknown	Carcinogenic; toxic by ingestion, inhalation, or skin absorption, hygroscopic
1995.19.57 I	Iron Arsenite & Strychnine	Arsenic was used as a synthetic chemotherapeutic agent and as a syphilis treatment, specifically in a compound called arsphenamine.	Today used in the manufacturing of insecticides	1 g	Toxic by inhalation and ingestion; light sensitive; causes damage to central nervous system
1995.19.57 H/J	Phenolsulphthalein (Phenol Red)	Laxative, also used as a renal test to test for kidney failure; injected intravenously	Today used as a pH indicator; may cause cancer in humans	30–200 mg daily to act as a laxative	Toxic by ingestion and inhalation; a strong irritant; only 0.25 mg of arsenic is needed to cause fatality; possible carcinogen, suspected of causing infertility
1995.19.59 A	Mulford Hypo-Unit	Used to store hypodermic needles, made of nickel	N/A	N/A	Flammable, may cause cancer, may cause damage to fertility and/or unborn child

TABLE 4, continued

Museum Coding	Item	20th-Century Use	Present-Day Use	Dosage	Safety Concerns/
1995.19.59 B	Atropine Sulfate	To inhibit salivary and bronchial secretions, for cardiopulmonary resuscitation, management of acute myocardial infarctions (heart attacks)	Used to treat low heart rate; antimuscarinic agent; used to reduce salivation and bronchial secretions before surgery; antidote for cholinergic drugs	Unknown	
1995.19.59 C/F	Digitol Aqueous	For cardiac disease	Unknown	Unknown	Atropine is toxic if inhaled or ingested. It is fatal if swallowed; hygroscopic
1995.19.59 D	Strychnine	Increases reflexes. When heated, emits highly toxic fumes. Remedy for heart and respiratory complaints, acts as a stimulant	Rat poison	Unknown	Unknown
1995.19.59 E/H	Nitroglycerin	To prevent chest pain (agina) in patients with heart conditions, hypertension	To prevent chest pain (angina)	Unknown	Toxic if ingested; poison.
1995.19.59 G	Camphor in Oil	Relieve pain, irritation, itching (natural oil)	Creams, ointments, and lotions	N/A	High doses can cause headaches, dizziness, lightheadedness, tremors, convulsions, mental confusion, and even death
1995.19.59 I	Caffeine Benzoate (Caffeine Sodium Benzoate)	Stimulate heart and breathing, wanted to counteract diminished blood pressure/respiration during anesthesia (for low blood pressure)	Treat respiratory depression (hypoventilation), but is not approved by the FDA	500 mg; total dose should not exceed 2.5 g in 24 hours.	No known hazards
1995.19.59 J	Cardiac ((R)-(-)-Phenylephrine Hydrochloride)	Anti-inflammatory, cold medicine, decongestant	Anti-inflammatory, cold medicine, decongestant	Unknown	Large doses may cause headaches, agitation, a condition resembling anxiety; neurosis, muscle twitches, etc; targets the central nervous system and the heart
1995.19.63 B	Catgut, non-boilable	Serve as sutures. Made of dried and twisted intestines of cattle, i.e., sheep, horses, cows, goats; packaged in an alcohol solution (ethanol and isopropanol), in order to retain flexibility	Still used today	N/A	No known hazards
1995.19.63 C	Bauer & Black Sterile Chromic Catgut (Boilable)	Serve as sutures. Preserved in xylol, toulene-99.75%, phenyl mercuric acetate-0.025%	Still used today	N/A	No known hazards
1995.19.62 C	Aposthesine	Anesthesia	Not used because of its toxicity	For injection,	No known hazards
1995.19.7	Ribothiron, made of Ferrous Sulfate with Vitamin B2, Thiamine Hydrochloride, and Riboflavin	Iron deficiency anemia	N/A	1-2%, typically with epinephrine	Toxic; today, lidocaine is commonly used

Examination and Testing

In the laboratory setting, four variables were tested: (1) temperature, (2) ambient air/moisture, (3) water sensitivity, and (4) light. Four vials of each chemical were prepared and labeled according to the variable being tested. As the variables were monitored and altered, the composition of the select chemicals (the regenerated contents) appeared to experience a chemical change. Some of the variables, such as water sensitivity, appeared to have no sign or evidence of a chemical change. The variables of temperature, light, and ambient air were shown to strongly influence the stability of the regenerated contents.

Hypothesis

In the present state, the contents of the collections 89.23.1, 95.19.0, and 95.19.1, if stored in a dry, dark place, will be stable and can be maintained for an extended period of time. These contents are suitable for display for exhibition purposes. Hazards may only occur if placed in direct sunlight. It is suggested that with extreme heat the components are likely to be destroyed and degraded. Based on the safety concerns associated with the contents (listed in Table 1), we recommend that they are safe to handle and display, as long as they are not broken or unsealed.

Evidence

Temperature

The ambient temperature of the lab was 67 °F. However, the change in temperature of the regenerated contents was studied from 32–158 °F. This range of temperature was chosen to represent exposure of the contents to extreme cold (A/C overload) or heat (loss of A/C). Table 2 shows an overview of the chemical changes recorded when the regenerated contents were exposed to a change in temperature. The variable of temperature did not influence caffeine benzoate, strychnine nitrate, and Apothesine. Dramatic changes were noted when the regenerated contents were exposed to high temperatures (Table 2).

TABLE 5: Museum Contents upon Exposure of Temperature Changes from 0 °C (32 °F) to 70 °C (158 °F)

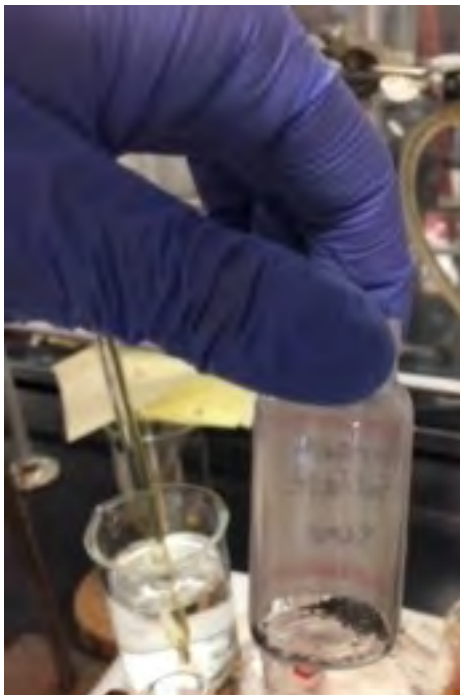
Item	Temperature (10/09/19)				
	0 °C (32 °F)	30 °C (86 °F)	40 °C (104 °F)	50-60 °C (122-40 °F)	70 °C (158 °F)
Atropine Sulfate	No change	No change	Evaporation occurring, water residue	Evaporating continued to occur	Burnt, residue is black; decomposed
Camphor in Mineral Oil	Clear liquid, higher viscosity	Bubbles forming	More bubbles forming on liquid	Evaporating, gas produced, white solid precipitate has formed	Color change of liquid, slight yellow
Nitroglycerin	No change	No change	No change	No change	Evaporated
Caffeine Benzoate	No change	No change	No change	No change	No change
Mercuric Salicylate in Quinine & Urea Hydrochloride (1-2%)	Precipitate formed	Opaque, cannot see precipitate	Evaporating, condensation forming on walls of vial	Boiling	Quinine and Urea Hydrochloride solution evaporated, solid decomposed
Quinine Hydrochloride	No change	Evaporating, gas emitted, a brown liquid forming	Black precipitate on bottom of vial	Black precipitate on bottom of vial	Burnt, decomposed
Sodium Cacodylate	No change	Solid melting, liquid forming	Liquid evaporating	Solid residue, mass lost; decomposed	---
Strychnine Nitrate	No change	No change	No change	No change	No change
Phenolsulphone-phthalien	No change	No change	Evaporation occurring, condensation on walls of the vial	50% of liquid (distilled water) has evaporated	Liquid evaporated
Iron Arsenite & Strychnine	No change	Gas emitted, precipitate at bottom of vial mixing	Boiling, emitting gas	Boiling, emitting gas	Decomposed, orange residue left on walls of vial
Apothesine (Cinnamic acid, 3-(Diethylamino) propyl Ester, Hydrochloride)	No change	No change	No change	No change	No change
Ferrous Sulfate (Ribothiron)	No change	Blue crystals turned black	Color of solid changed to brown	Brown solid	Burnt, decomposed
Mercury Succinimide	No change	No change	No change	White crystals turning light brown	Decomposed, burnt, crystals turned brown where touching the bottom of the vial
Cardiac (R)-(-)-Phenylephrine Hydrochloride	No change	No change	No change	Liquid started to form	Water on bottom of vials, precipitate dissolved

Light and Ambient Air

A set of the chemicals was studied to provide information about the stability of the regenerated contents when opened to determine the effect of ambient air. All samples were observed over a two-month period. The variable of light was first observed over a period of four consecutive days to determine short-term effects. The samples were then reviewed about two months later to determine any long-term effects of the light variable. This variable was studied to provide the museum with an idea of the stability of the compounds should the containers break while in use/storage/handling. The experimental procedure was designed with both exhibition and storage in mind.

Ms. Ramos measured approximately 0.025 g of each solid component into the vial. Select samples contained 0.05 g of the solid, as some of the chemicals were more brittle and clumped together. Simultaneously, two sets of samples were created to observe the effect of light exposure. One set was placed on a window ledge that experienced direct amounts of sunlight on a daily basis. A second set was placed in a cabinet in the dark. The lids of all vials were removed to allow proper exposure to the ambient air. Table 3 outlines the results when the samples were exposed to direct sunlight and open air. Table 4 details the results when the samples were kept in complete darkness.

FIGURE 11: Ferrous Sulfate decomposing at approximately 86 °F



Initially, ferrous sulfate was present as blue crystals. When exposed to water and air, the ferrous sulfate changed into an orange liquid, most likely due to the iron in the ferrous sulfate reacting with water and moisture in the air. Another chemical mixture, mercuric salicylate in a quinine and urea hydrochloride solution, reacted when exposed to the same conditions. Over time when exposed to the light and air, the sample composition evaporated and led to a small amount of solid in the vial. We have not identified the chemical composition of the solid. Upon further request by the museum, we can conduct additional studies. Similar observations were noted when the phenol red solution was exposed to the light and air.

Due to financial expense and governmental regulations, we studied the effects of nitroglycerin for select variables: ambient air, temperature, and light. A 1.0 mL sample of nitroglycerin was split into two samples. When the nitroglycerin sample (0.5 mL) was left in light and ambient air, the contents evaporated after four days.

Dark and Ambient Air

In addition to the light study, the samples were monitored over a two-month period when left in ambient air in the dark. The phenol red evaporated completely and a red powder residue remained. After two weeks, the mercury salicylate and phenol red in the open air and the light condition evaporated completely, and a slight solid residue remained in the vials.

The ferrous sulfate underwent a major change. On day one, the ferrous sulfate was present as blue crystals. After four days, the ferrous sulfate was present as a yellow liquid. This was most likely due to the iron reacting with the oxygen atoms in the distilled water.

Moisture

Ms. Ramos measured approximately 0.025 g of each solid component into the vial. Select samples contained 0.05 g of the solid, as some of the chemicals were more brittle and clumped together. Table 5 outlines the results when the samples were exposed to moisture. These samples were left in the sunlight, with the caps on. The effect of moisture was first observed over a period of seven days to determine short-term effects. The samples were then observed about two months later to determine any long-term effects of the water variable.

Some of the chemicals dissolved completely with the water; however, others were insoluble in water. Strychnine nitrate formed a cloudy liquid when mixed with 0.5 mL of distilled water. When mixed with 0.5 mL of distilled water, mercury succinimide formed an opaque white liquid.

TABLE 6: Samples Exposed to Direct Sunlight and Open Air, with the Caps Off

ITEM	Observations				
	Day 1 09/24/19	Day 2 09/25/19	Day 3 09/26/19	Day 4 09/27/19	Day 72 12/02/19
Ferrous sulfate	Blue Crystals	Blue Crystals	Blue Crystals	Blue Crystals	Decomposed
Mercuric Salicylate in Quinine & Urea Hydrochloride (1-2%)	Cloudy, liquid	Cloudy, liquid	Solid settled to the bottom	Solid settled to the bottom	Decomposed
Phenol Red (1 mL of water)	Red liquid	Red liquid	Red liquid	Dark liquid settled at bottom, lighter layer on top	Decomposed
Atropine Sulfate	White solid	White solid	White solid	White solid	Decomposed
Caffeine Sodium Benzoate	White, clumpy solid	White, clumpy solid	White, clumpy solid	White, clumpy solid	Decomposed
Camphor in Mineral Oil	Clear liquid	Clear liquid	Clear liquid	Clear liquid	Clear liquid
Sodium Cacodylic	White, clumpy solid	Clear liquid	Clear liquid	Clear liquid; solid completely disappeared	Decomposed
Strychnine Nitrate	White, grainy solid	White, grainy solid	White, grainy solid	White, grainy solid	Decomposed
Aposthesine	White solid, powder	Liquid formed, still some solid remaining	Liquid formed, most of solid dissolved	Liquid formed, some solid remaining	Decomposed
Cardiac	White solid chunks	White solid chunks	White solid chunks	White solid chunks	Decomposed
Quinine Hydrochloride	White solid	White solid	White solid	White solid	Decomposed
Mercury Succinimide	White crystals	No change	No change	No change	Decomposed
Iron Arsenite	Yellow liquid	Solid settled to the bottom, with relatively clear liquid remaining on top	No change	No change	Decomposed

TABLE 7: Samples Exposed to No Sunlight and Open Air, with the Caps Off

ITEM	Observations				
	Day 1 09/24/19	Day 2 09/25/19	Day 3 09/26/19	Day 4 09/27/19	Day 72 12/02/19
Ferrous sulfate	Blue Crystals	Blue Crystals	Blue Crystals	Blue Crystals	Decomposed
Mercuric Salicylate in Quinine & Urea Hydrochloride (1-2%)	Cloudy, liquid	Precipitate settled to the bottom of vial	Precipitate settled to the bottom of vial	Precipitate settled to the bottom of vial	Decomposed
Phenol Red (1 mL of water)	Red liquid	Red liquid	Red liquid	Red liquid	Decomposed
Atropine Sulfate	White solid	White solid	White solid	White solid	Decomposed
Caffeine Sodium Benzoate	White, clumpy solid	White, clumpy solid	White, clumpy solid	White, clumpy solid	Decomposed
Camphor in Mineral Oil	Clear liquid	Clear liquid	Clear liquid	Clear liquid	Clear liquid
Sodium Cacodylic	White, clumpy solid	Clear liquid, still some solid remaining	Clear liquid, most of solid dissolved	Clear liquid	Decomposed
Strychnine Nitrate	White, grainy solid	White, grainy solid	White, grainy solid	White, grainy solid	Decomposed
Aposthesine	White solid, powder	Liquid formed, still some solid remaining	Clear liquid, most of solid dissolved	Clear liquid	Decomposed
Cardiac	White solid chunks	White solid chunks	White solid chunks	White solid chunks	Decomposed
Quinine Hydrochloride	White solid	White solid	White solid	White solid	Decomposed
Mercury Succinimide	White crystals	No change	No change	No change	Decomposed
Iron Arsenite	Yellow liquid	No change	No change	No change	Decomposed

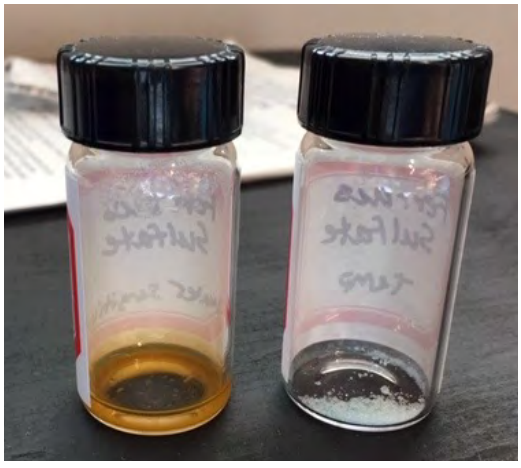
FIGURE 12: Mercuric Salicylate in the Open Dark Condition (Left) and Open Light Condition (Right)

Water Sensitivity

TABLE 8: Samples Exposed to Distilled Water (Variables of sunlight and no exposure to air were maintained as constants. The caps of the vials were left on.)

ITEM	Observations				
	Day 1 (10/04/19)	Day 5 (10/08/19)	Day 6 (10/09/19)	Day 7 (10/10/19)	Day 60 (12/02/19)
Ferrous Sulfate	Slight bluish, clear liquid	No change	No change	Slight change in color	Yellow liquid
Mercuric Salicylate in Quinine &Urea Hydrochloride (1-2%)	Cloudy liquid, solid resting at top	No change	No change	No change	No change
Phenol Red (1 mL of water)	Red liquid	No change	No change	No change	No change
Atropine Sulfate	Clear liquid	No change	No change	No change	No change
Caffeine Sodium Benzoate	Clear liquid	No change	No change	No change	No change
Camphor in Mineral Oil	Clear liquid	No change	No change	No change	No change
Sodium Cacodylic	Clear liquid	No change	No change	No change	No change
Strychnine Nitrate	Cloudy, white, opaque liquid	No change	No change	No change	No change
Aposthesine	Clear liquid	No change	No change	No change	No change
Cardiac	Clear liquid	No change	No change	No change	Changed color, brown tint
Quinine Hydrochloride	Clear liquid	No change	No change	No change	No change
Mercury Succinimide	Cloudy, white, opaque liquid	No change	No change	No change	No change
Iron Arsenite	Yellow liquid	No change	No change	No change	No change

FIGURE 13: Ferrous Sulfate in the Condition of Water Sensitivity (Distilled water (0.5 mL) added to ferrous sulfate (0.1 g).)



External Analysis of Lygel and Blood Samples

In these kits, there were two very unique and interesting contents: a rusting Lygel ointment (95.19.47 D) and brittle gauze with dried blood spots (95.19.56 O–P). Samples from these contents were taken and submitted for external analysis.

Lygel – 95.19.47 D

This was used as an antiseptic jelly meant to prevent the growth of disease-causing microorganisms. This tube has visible evidence of rust and exposure to air. The curator at The Columbus Museum indicated an interest of identifying the contents and determining whether the corrosion was a concern for an exhibition and storage. In image DSC_3044.JPEG, the directions state that this jelly was used with a douche to help clean the reproductive area of female patients. In the directions, there is mention of Lysol. The benzene ring in the Lysol was also present in the diethyl phthalate in the non-rusted Lygel sample. The main active ingredient in Lysol was benzalkonium chloride. Lysol was used in the 1920s for feminine hygiene issues.

To identify the chemical components of the aging tube, samples were sent to the Mass Spectrometry Lab at Auburn University for analysis and comparison of a native (non-rust) sample with a rusted sample. Samples were collected by a generic q-tip and messengered to the Auburn labs.

The ends of 95.19.56 D, rust, and blank q-tip were cut off with a clean scalpel, and 300 μL of hexanes and 300 μL 50% water 50% methanol were added. Samples were vortexed and sonicated well. The liquid was centrifuged to separate the layers; the hexanes were analyzed by GC-MS, while aqueous was analyzed by LC-MS in positive and negative modes after separation on a Waters BEH C18 column.

Visible differences in the LC-MS total ion chromatograms are faint, so extracted ion chromatograms were generated to show the ions that appeared different in the samples. Possible chemical formulas have been generated and/or isotope models given for the compounds found in higher abundance in the samples than in the q-tip blank. There is some evidence for the weak inorganic elements, and ICP-MS or atomic absorption would be better suited to identify the inorganic compounds. Select organic compounds were identified in the non-rust and rust samples. In the rust sample, decamethylcyclopentasiloxane, dodecamethylcyclohexasiloxane, and tetradecamethylcycloheptasiloxane were noted, while in the non-rust sample, diethyl phthalate and undecane were detected.

FIGURE 14: Schematic representation of Benzalkonium Chloride

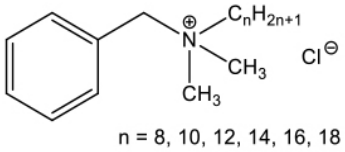


FIGURE 15: Schematic representation of Decamethylcyclopentasiloxane

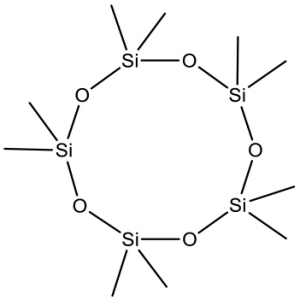


FIGURE 16: Schematic representation of Dodecamethylcyclohexasiloxane

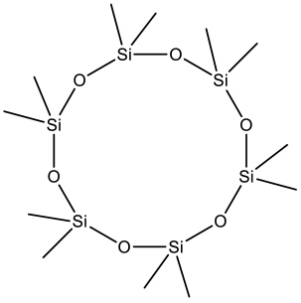


FIGURE 17: Schematic representation of Dodecamethylcyclohexasiloxane

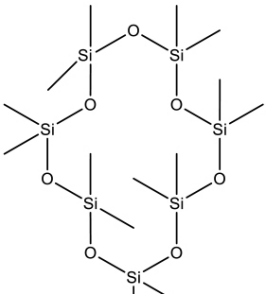


FIGURE 18: Schematic representation of Diethyl Phthalate

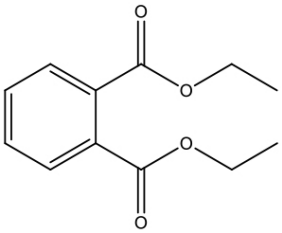


FIGURE 19: Schematic representation of Diethyl Phthalate

Lygel in the 1920s

The use of the antiseptic ointment Lygel can be considered odd but suprising. According to a HuffPost article, women in the 1920's used Lygel for feminine hygiene issue and odors. This product was used as an aid to spice up a couple's "love life behind closed doors." An example of these ads from that time period, which were meant to encourage women to wash routinely, appear below. The article further states that "Lysol brand antiseptic disinfectant first appeared on the scene in 1889 as a way to help end a cholera epidemic in Germany. In 1918, ads touted it as an effective means to fight the flu virus during the influenza pandemic" (Bologna, 2018).

FIGURE 20: Lysol ads from the 1920s (Source: Bologna, 2018)

However, in the present day (21st century), we know that Lysol is used as a disinfectant to protect against harmful germs on a variety of surfaces.

Blood Samples – 95.19.56 O-P

Samples of the brittle gauze and the dried blood spots were taken and submitted for external analysis at the Mass Spectrometry Lab at Auburn University. Chromatograms were provided in a supplementary document as pdf files. Excel files (csv) were acquired and contained both positive and negative ions. These provide the peak height and area for the ions at the different retention times to help the Taylor Group query the human metabolome database (hmdb.ca) in order to find tentative identities.

Upon review, over 3900 items were quantified and identified by the human metabolome database (hmdb.ca). The prevalence and validity of such metabolites is being reviewed further by the Taylor Group. If there is sufficient interest, the samples can be further reviewed for other genetic information. However, this analysis may have an associated expense.

Limitations with the Blood Analysis

The Taylor Group hoped to conduct further analysis to determine the background and potential recipient(s) of the blood samples located on the soiled gauze. Initial discussions were completed with forensic chemist and CSU alumna, Mrs. Victoria Oehrlein, to distinguish a method and company for testing the blood sample. She submitted a number of commercial labs that were capable of executing DNA testing. However, the experts who were contacted noted some possible complications with DNA analysis. Since January 2020, a number of commercial labs were contacted to determine the possibility and method of analysis. However, two factors, separation of extraneous DNA and financial cost, ultimately ended our inquiry.

Factor 1: Extraneous DNA

The blood samples, item 95.19.56 O–P, is from the 20th century (1920–1940's) and likely has come into contact with a number of clinical professionals, patients, family descendants, museum personnel, scientists....to name only a few. This complicates analysis as we would not know whose DNA is truly belonging to the blood stain. Like the museum personnel, the Taylor Group wore gloves at all times and made sure to maintain the composition of the items. In a forensic lab setting, DNA samples are compared against a known roster of individuals to decipher the true candidate. In this case, there are too many "knowns" to account for in this 100-year gap between the gauze being soiled and the present analysis.

Our interest in the blood samples was to understand the details associated with the dried blood. Blood can have many descriptors—gender, age, type, etc. These three kits were used by three different clinicians with the intention of serving the community of Columbus, Georgia as general practitioners. This means that the blood samples could be from patients of any age (i.e., baby, child, or adult) or gender (female or male). Furthermore, these blood samples could have been contributed by more than one source. In fact, these samples could be from multiple patients or the clinicians themselves. The commercial labs mentioned that the samples were to be considered ancient, which likely meant that they would not withstand the analysis. The Taylor Group would not be confident in reporting our findings to the museum.

Factor 2: Financial Cost

Multiple discussions with commercial labs revealed that the analysis would cost a minimum of $2,000–3,000. Our budget did not allow for such an expenditure. The associated cost was not something that the Taylor Group or The Columbus Museum considered essential, which ended our inquiry.

Recommendations

We recommend that for exhibition purposes the contents be displayed in indirect sunlight or under ambient light. This would allow for the contents to continue to "live" among the collection's contents and maintain their integrity. The museum maintains a temperature that should preserve the medicines.

Short-Term Maintenance

Short-term maintenance would include keeping all of the chemicals and medicines in a consistent temperature between 32–86 °F. When in exhibition, the optimal temperature can maintain the integrity of the chemical components and provide a favorable experience for the patrons. It may be best for these medicines to be positioned in an enclosed environment and away from water, in order to protect them from any damaging conditions, such as potential water damage in the case of a leak or a flood.

Long-Term Maintenance

Long-term maintenance would include keeping all of the chemicals and medicines in storage where the temperature remained above 32 °F and under 86 °F. The museum keeps the temperature at about 70 °F, which is an optimal temperature for maintaining the integrity of the chemical components. When in storage, it may be best for these medicines to be packaged in plastic bags to protect them from any damaging conditions, such as potential water damage in the case of a leak or a flood.

Key Words & Definitions

Non-Ketonic Hyperglycemia

A rare genetic disorder that results in the accumulation of glycine within the body's tissues and fluids, due to a compromised enzyme system that fails to break down glycine. Glycine is an amino acid, used to make protein in the body. It is also a neurotransmitter. Glycine is sometimes used to treat schizophrenia and other disorders involving the brain.

FIGURE 21: Symbols of chemical hazards (Source: Kemsley, 2012)