

In the Classroom

Conservation A Collaboration Between Art and Science

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This article presents an overview of the major causes of the decay of artifacts and antiquities. It summarizes various interactions of the environment with different types of artworks that lead to their eventual degradation. In their effort to preserve our heritage and comprehend the causes of decay, museums and art experts are increasingly utilizing the tools of science. Scientific analytical laboratories, equipped with “state of the art” instrumentation, have already become an integral part of some famous museums. This article also describes the development of a new trend in the art of modern conservation, which emphasizes the necessity of keeping the original intention of the artist intact and preserving the integrity of the artifact.

Prologue

Science educators in colleges and universities throughout the

United States have been actively involved in developing new and innovative science courses through which nonscience undergraduates may fulfill their science requirements. Courses with emphasis on the application of science in everyday life and those which are interdisciplinary in nature have proven to appeal more to students in the humanities than the traditional condensed introductory courses offered in a certain discipline (biology, chemistry, physics, etc.). A rich vintage of new courses and approaches resulted, but one of particular interest is “Chemistry and Art” [1]. This course was introduced in the 1970s by P. J. Ogren, D. L. Bunse [2], and M. V. Orna [3]. Since then, many who teach it have made modifications to fit the needs and interests of a particular student population. Two applications that students have always found fascinating are the conservation and authentication of artworks. This paper is a brief discussion of the artworks of conservation and references suitable for classroom and reading assignments are given.

Introduction

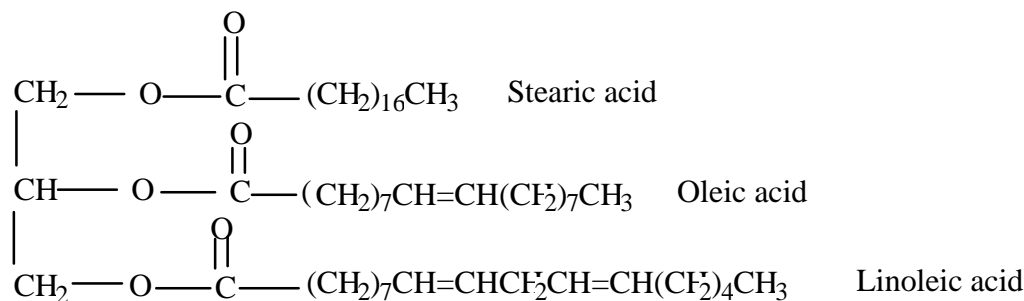
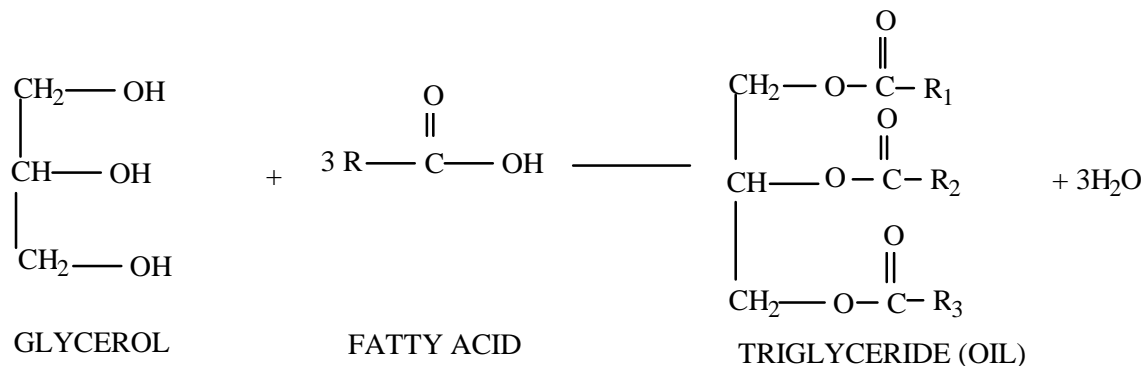
Other than vandalism and accidental damage, the environment is the main cause of the decay of artworks and antiquities. Oxygen in the air, air pollutants produced by the burning of fossil fuels, light, and changes in temperature accompanied with changes in humidity are cumulatively responsible for the inevitable decay of artifacts. Additional factors, such as dust, soot, and fungi, aid this decay process. Art conservators with the support of analytical science attempt to intervene to stop the deterioration, restore the artifact, and take measures when possible to prevent further decay. In some cases conservation efforts cannot stop the deterioration process or reverse the ensuing damage, but they can help slow the rate of destruction to ensure a longer existence for the artifact.

As soon as an artifact is created, chemical reactions with all the environmental factors cited commence. With time each will leave its signature and threaten the continued existence of the artifact. It is first necessary to understand how artifacts interact with the environment in order to determine what methods to use to halt or prevent their decay. A painting, for example, is a complex mixture of pigments, vehicle, and binder that are layered on a support such as paper, canvas, wood, or stone to create an image. A knowledge of the chemical composition of those parts and their interaction with matter and energy in the environment is significant to the preservation of the painting.

Environmental Factors

Atmospheric Oxygen

In oil-paint, the vehicle used to spread the colored pigments is a “drying oil.” Linseed oil, extracted from the seeds of the flax plant, is the most popular among artists because of its lower tendency to crack or yellow on aging. A drying oil is a polyunsaturated triglyceride.



TYPICAL TRIGLYCERIDE

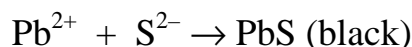
When spread in thin layers, the unsaturated oil interacts with oxygen in the air and polymerizes at a reasonable rate (a process commonly called drying [4], to form a solid surface that is resistant to chemical attack, thus helping to fix and protect the pigment. The higher the degree of unsaturation the faster the polymerization rate. Olive oil or coconut oil are examples of monounsaturated or saturated triglycerides, respectively, and they are classified as “nondrying” oils. They take a long time to polymerize; hence, they are not suitable for paintings. If the oil content of paint is inadequate, the paint will eventually start to flake. This is the case with the paintings of Georgia O’Keeffe, a 20th century American artist (1887–1986). She kept the oil in her paintings to a minimum in order to produce a dry, velvety appearance. When her

paintings began to flake, varnish had to be applied to many of them to rectify the problem [5].

To saturate and enhance the colors, oil paintings are generally varnished with a natural resin dissolved in mineral spirits and applied to the surface in a thin layer to make it smooth and glossy. It is widely believed that varnish also helps to protect the painting. Dammar, copal, and mastic, which are most commonly used as varnishes, are naturally occurring resins (polymers)—the exudates of various types of trees [4]. Unfortunately, oxygen in the air oxidizes the varnish and turns it into a yellow film that dulls the colors that it once enhanced. Exposing the varnish to ultraviolet light accelerates the yellowing and cracking process. Because natural resins are soluble in organic solvents, the varnish can be removed during cleaning. Cleaning a painting, besides removing the dust and grime, involves the careful removal of the varnish layer by suitable solvents such as acetone, toluene, ether, or ethanol. Care must be exercised in order to avoid removing some of the pigment with the varnish, which gives the painting a “skinned” appearance [6]. Progress in polymer chemistry research and the subsequent production of synthetic resins and polymers have given the conservator new and improved materials that can be utilized as varnishes. Synthetic resins with the same physical properties as Dammar or mastic, but with the advantage of less yellowing and cracking, have been developed and are used in conservation laboratories [7, 8]. Reversibility is an important aspect of modern conservation. Any changes made to the artifact must be such that they can be undone and the artifact returned to its original condition. Some synthetic resins have been shown to cross-link upon drying and become insoluble with time, a characteristic that has made them unsuitable for conservation. Moreover, some artists and conservators still argue that the visual beauty of natural resins has yet to be surpassed [7].

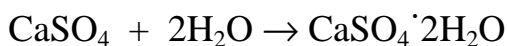
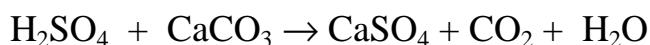
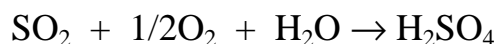
Air Pollutants

Atmospheric pollutants, caused primarily by burning fossil fuels, contain oxides of sulfur and nitrogen (SO₂, NO, and NO₂), which have a dramatic effect on the deterioration of artifacts. Sulfides in the air react with pigments such as white lead to form lead sulfide, a black pigment which causes the graying of white colored areas according to the following reaction:



Other pigments react with sulfides in a similar manner, for example, azurite blue ($2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$) turns to brown or dark green due to the formation of copper sulfide (black).

Stone and metal monuments and sculptures, especially those in the open air may be severely corroded by pollutants, mainly oxides of sulfur, which on combination with moisture, produce sulfuric acid, the source of acid rain. Marble, which is made of crystalline calcium carbonate (CaCO_3) formed under high temperature and pressure, reacts with sulfuric acid to form gypsum (calcium sulfate), a powdery chalklike material. Calcium sulfate then absorbs water from the rain and becomes the dihydrated salt which has higher solubility than the carbonate, and is washed away by rain [9]. The deterioration of marble by acid rain can be expressed by the following chemical reactions:

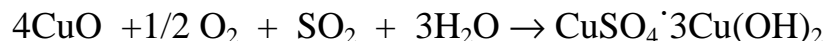


The Acropolis in Athens is a good example of the dramatic effect of pollution on marble [10]. The ancient temples and structures that withstood the ravages of time, earthquakes, and wars have been severely corroded by air pollutants. In 1975 the Greek government started a restoration effort to preserve the Acropolis. Severely corroded marble structures such as the Caryatids supporting the porch of the Erechtheum were moved indoors into the Acropolis Museum and were replaced outside by cement replicas. Missing pieces were replaced with exact replicas, with the date of installments engraved, so that future restorers can differentiate between the originals and those added by restoration. In an effort to fortify the marble, past restorers used iron rods and clamps, which rusted and stained the marble, accelerating its deterioration. Conservators had to remove the iron rods and replace them with titanium rods. Conservators used titanium because it is a hard, light, and nonrusting metal. Further conservation measures were taken to slow the deterioration of the ruins. Only gasoline with low sulfur content is allowed as heating and car fuel; and planes and cars are routed away from the area around the Acropolis [10, 11].

Other pollutants in the atmosphere are also major contributors to stone decay. Oxides of nitrogen react with moisture to form nitric acid, which will also slowly dissolve the stone. Nitrate deposits on the stone serve as food for microorganisms leading to biodegradation. Because of the varied chemical composition of the different types of stone (marble, granite, mica, etc.), there is no single unified method that can be used to stop deterioration. Conservators suggest that treatment should include, “cleaning agents, consolidants, water repellents, biocides, mortars, and coatings,” and they propose an interdisciplinary team of scientists to carry out the conservation task [12].

Similarly, sculptures made of metals such as iron, copper, or bronze are also corroded by sulfur dioxide and its acid product sulfuric acid, which is corrosive to most metals. Corrosion of metals is an electrochemical redox reaction. Parts of the metal act as anode where oxidation takes place (pits appear), and other parts act as cathode where reduction takes place (rust deposits appear) [13].

Copper is a fairly nonreactive metal with a good resistance to corrosion as is evident from its standard reduction potential of +0.34 V. Copper, however, reacts with oxygen at ambient temperature to form copper oxides, which in the presence of sulfur dioxide in polluted air are converted to brochantite, $\text{CuSO}_4 \cdot 3\text{Cu}(\text{OH})_2$. The net reaction can be represented by the following equation [13a]:

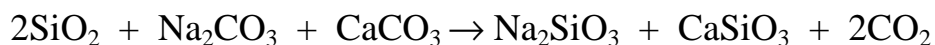


The reaction of copper with sulfides in the atmosphere gives copper sulfides, which constitute part of the corrosion layer. Likewise, carbon dioxide in the air dissolves in rain to produce carbonic acid, which also reacts with copper to give green malachite, $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$, or blue azurite, $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$. These corrosion products are what give copper its green-blue patina.

Bronze is an alloy of copper, tin, and lead. It is a harder metal than copper and more attractive to some, but is less resistant to corrosion. This is because tin is more reactive than copper (standard reduction potential is -0.14 V). In addition to the copper-corrosion products discussed above, the bronze patina contains corrosion products of tin and lead. Tin corrodes to form tin(IV) oxides, a surface that is resistant to further oxidation. Lead, which is added to bronze to improve its fluidity, reacts with carbon dioxide and moisture to form lead carbonate, PbCO_3 .

The green patina that forms on the surface of copper and its alloys, a mixture of all the above, serves as a decorative and protective surface for the metal below. Cracks in this patina, or sometimes the porosity of the metal oxide, allow the corrosion reactions to reach to a newly exposed inner metal surface and further corrode the metal. The presence of chlorides in the atmosphere, coming from salt (sea water) or industrial pollution, catalyzes the decay process and causes what is known as “bronze disease.” The chloride ion replaces the hydroxide ion and forms a soluble metal chloride which is hygroscopic in nature. It reacts with water to produce hydrochloric acid, causing pits in the metal and if left unchecked may lead to its demise [13].

In addition to their detrimental effects on stone and metals, sulfur dioxide and sulfuric acid also attack medieval stained glass. Gottfried Frenzel [14], explains how Europe’s most radiant art is “victim to its own composition and of modern air pollution.” Window glass (soft glass) is prepared by melting silicon dioxide with carbonates of sodium and calcium according to the following reaction:



Sulfuric acid reacts with alkali metal ions in the glass, such as potassium or sodium, and with calcium ions forming sulfates, which are chalky and opaque. As this crust is washed away, a new surface is exposed and the process continues. Pits start to appear in the glass panels. This is happening at the Canterbury Cathedral in England and the Chartres Cathedral in France. The perforated panels then allow acid rain to attack the inner surface of the glass causing even more damage. Moreover, the weathered crust is hygroscopic in nature, it absorbs water and accelerates the deterioration process. Water attacks the glass by replacing the alkali metal ions with hydrogen ions, and the hydroxide ions in turn attack the silica (SiO^2), breaking its polymeric bonds and producing shorter fragments with an opaque appearance. Other than keeping the glass dry, Frenzel suggests double glazing as a possible solution to this problem. A pane of glass not attached or glued to the stained glass can be used as a lining to protect the exterior of the stained glass from pollutants. Humidity and temperature between the two panels should be controlled. The inner surface of the glass can be protected by the provision of a controlled climate combined with an air-filtration system similar to a museum environment.

Light

Light is another harmful factor to many paintings and artifacts [15]. Light is a form of energy and can interact with chemicals and change their composition and structure. The exposure of paintings to ultraviolet light causes the fading of many pigments and dyes. Exposing varnishes to ultraviolet light speeds up the yellowing and cracking process. Light weakens the natural cellulose fibers in paper and textiles and causes them to become brittle. When a piece of paper is exposed to sun light for a period of time, it becomes yellow and brittle. On absorbing UV radiation the polymeric bonds between the monomeric units start to break. Because light is such a powerful enemy of artifacts, museum lighting is controlled and free of UV radiation; hence, windows are glazed with a UV absorbing plastic shield [16]. The effect of light on artifacts is cumulative; consequently, flash photography in many museums is prohibited.

Temperature and Humidity

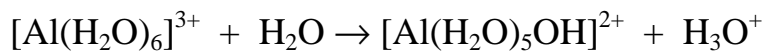
Humidity and temperature in museums should be controlled. On absorbing moisture the canvas in paintings expands and on drying it shrinks. If accompanied by changes in temperature, repeated expansion and shrinking can induce severe cracks in the paint and cause it to flake. Variations in temperature and humidity are also the basic cause of cracks in tempera paint on wood panels and wooden furniture.

In order to preserve one particular painting by Georgia O’Keeffe, “Black Hollyhock, Blue Larkspur”, in its original unvarnished state with its rich velvety colors, conservators at the Metropolitan Museum of Art in New York City, placed it in a glass box containing silica-gel pellets [5]. Silica gel is a desiccant that absorbs moisture from the surrounding atmosphere. This conservation measure will help keep the moisture content inside the box constant, relieving the stress on the canvas, which reduces the risk of flaking, as well as protecting the surface from dust and environmental pollutants.

Ceramics and stone artifacts are porous substances that are capable of absorbing moisture and that are gravely affected by large changes in temperature and humidity. For example, the salts absorbed in the pores of stone tend to dissolve in a humid atmosphere, a process known as efflorescence. The dissolved salts then migrate in the stone and crystallize in different pores creating pressure, which can cause the stone to crack. The salts can likewise migrate to the surface of the stone causing considerable damage and posing a serious problem in fresco paint (painting on fresh lime) or wall

paintings. Such is the case of the Lascaux cave in the Dordogne region of France, which contains about 600 paintings and nearly 1,500 engravings on the cave's walls and ceiling [17]. The cave was discovered in 1940 and was transformed into an underground museum, open to the public, after World War II. After two decades of tourism, the Paleolithic art treasures that had survived for about 17,000 years started to deteriorate. Humidity introduced by the visitors, in addition to dust, fungi, and other environmental factors, caused the colored pigments to fade. On absorbing moisture the salts in the stone dissolve, migrate to the surface of the stone through capillary action, and then, on drying, crystallize on the surface of the stone. As a result the stone will be stained and the colors dulled. Humidity also encourages mold and fungi to grow and further deteriorates the murals. To save the Old Stone Age murals and engravings the cave was closed to the public in 1963. Another limestone cave, believed to be about 20,000 years old and estimated to be five times larger than the Lascaux cave, was discovered near the town of Vallon Pont-d'Arc in France in January of 1995. French explorers found the Paleolithic paintings beautifully preserved in the dark and naturally sealed from the outside world underground cave [18]. Hopefully, the lessons learned from the Lascaux cave experience can be applied to preserve these paintings.

Humidity is also the major cause of deterioration of paper manuscripts. Paper is made of natural cellulose fiber. Since the 1750s, a sizing such as aluminum sulfate, $\text{Al}_2(\text{SO}_4)_3$, has been added to paper to prevent the ink from spreading and to make it suitable for printing. Aluminum ions react with water to form a hydration complex, $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$, which undergoes hydrolysis to produce the acidic hydronium ion according to the following equation:



The acid produced disrupts the cellulose fibers, makes the paper brittle, and causes the paper to crumble [19]. To prevent or slow the above reaction, paper documents should be kept in a dry and controlled atmosphere. Important documents are exhibited in a glass box in an inert atmosphere. Another factor that leads to the degradation of important paper documents, manuscripts, or books is the presence of plastic artifacts in museums. Cellulose nitrate (celluloid) is a polymer that was widely used in the manufacture of many types of plastics at the beginning of this century. Under the effect of light, celluloid decomposes to give nitrogen oxides, which react with water or moisture from the atmosphere to form nitric acid. The acid catalyses the decomposition

of the polymer itself, leading to its destruction, as is the case with old movie films. The acid produced disrupts the cellulose polymeric bonds in paper objects in a manner similar to that of sulfuric acid. Moreover, oxides of nitrogen are strong oxidants and are considered a fire hazard when adsorbed on dust covered paper [20]. For paper objects to last longer, the use of acid-free paper made from pure alpha-cellulose to which alkaline materials have been added is recommended [19].

Other Factors

Additional factors that cause damage to art and artifacts include mishandling, neglect, accidents, and vandalism. These also call for the skills and knowledge of the conservator and the scientist for mending and restoring. The effects of dust, fungi, and insects can be minimized in some cases by reducing exposure to them.

Modern Analytical Techniques Used in Conservation

Scientific analysis is emerging as an important tool for the conservation of paintings and other art objects. Before starting any restoration work, a very thorough analysis of the painting or artifact must be conducted. Many research instruments present in chemical laboratories, such as gas chromatographs, mass spectrometers, infrared spectrometers, and several others, have found their way into conservation laboratories. Some methods commonly used in analyzing a painting or an artifact are summarized below [21–23].

Microscopic Analysis

The artifact is examined with a microscope to help evaluate its overall condition. This can give a preliminary assessment of damages and reveal previous restoration efforts. A polarizing microscope can be used to analyze the type of pigments used.

Cross-sectional Analysis

A tiny sample of paint used by the artist is extracted from an already damaged area and embedded in a Plexiglas cube. Microscopic examination reveals the types of pigments used, the layering of the paint, and the style in which the artist builds-up his colors.

Ultraviolet Radiation

Observation under ultraviolet light gives valuable information on the varnishes and glazes used and shows areas of previous restorations. Organic materials absorb ultraviolet radiation and then emit it at lower energy (in the visible region) a

phenomenon known as fluorescence. If an artifact has been broken and then glued together using an adhesive followed by repainting, viewing under UV-light will make the break obvious due to the adhesive's fluorescence. For metal artifacts artificial patina glued to the surface is visible under UV-light due to the fluorescence of the glue.

Infrared Reflectography

This allows the conservator to look under the layers of paint and get a glimpse of the initial sketch of the artist. It gives insight into whether or not the artist altered his original sketch or if he had second thoughts (*pentimenti*). It can also be used to help clarify an artist's illegible signature.

Infrared Spectroscopy

Infrared spectroscopy gives information about the types of pigments or dyes used. On subjecting a thin transparent film of a compound to infrared light, certain frequencies are absorbed. This aids in identifying its composition.

Laser Raman Spectroscopy

Laser raman spectroscopy involves illuminating a sample with a monochromatic beam of light and analyzing the scattered radiation. It gives information on the structure and composition of a sample and eliminates interference from other pigments, binders, or from fluorescence [24].

X-Radiography

This method possesses the ability to penetrate layers of paint and reveals information about the priming layer, the canvas, and any damages hidden under the paint. It is used to detect lead-based pigments in the paint. White lead was extensively used and often mixed with other pigments in old paintings. In addition, it can detect the restoration of metal objects using adhesives or plaster of Paris, because the metal absorbs much more radiation than the plaster and gives a whiter image on the X-ray film [23].

Autoradiography [25]

Exposing a painting to low-energy neutron radiation causes it to possess transient radioactivity. On placing a film similar to that used in X-radiography against the painting one can obtain valuable information on the pigments used, their chemical composition, the style of the artist, and the paint layering or stratigraphy. The amount of radiation used is very low and it causes no harm to the painting. Initial

autoradiographs are dominated by elements of short lifetime, while autoradiographs at later intervals will be dominated by elements of longer lifetime. The only disadvantage is that the painting has to be removed and shipped to special laboratories equipped for this technique.

Conservation Past and Present

In the past restoration was performed by artists of the same discipline. The main objective of the effort was to improve the aesthetic appearance and conceal the fact that the article was damaged and repaired. The materials used were limited to beeswax, paraffin wax, flour paste, plaster, glue, gum Arabic, and powder pigments, but restorers employed innumerable methods of repair [23]. Their repair procedures were secretive and the restoration went undocumented. Secret recipes and procedures were used and were only passed to others through apprenticeships. Often restorers added their own touch and made changes they thought were appropriate without considering the original intent of the artist. There are extraordinary examples of how restorers of the past added their own style and sense of history to the original work.

Ian McClure, a paintings conservator and the Director of the Hamilton Kerr Institute's conservation center at the Fitzwilliam Museum (Cambridge, England) since 1983, describes the unexpected results from the painting of Henry Prince of Wales on horseback by Robert Peake the Elder [26]. He wrote that the painting showed the Prince of Wales in splendid armor on horseback with a tree spreading behind him and the Prince's plaque bearing his insignia hanging from a branch (Figure 1). Microscopic analysis showed two different painting styles; the prince and the horse were painted with meticulous details executed in thin-layered paint while the landscape was broadly executed and thickly painted. Subsequent examination by infrared reflectography and X-radiography gave images that clearly showed a totally different underlying landscape. The decision on whether to remove the over paint or keep it required a sense of the painting's history and the time frame during which it was produced. The painting was commissioned by the Prince and it dates to 1610. Further cross-sectional analysis of a pigment sample embedded in a Plexiglas cube revealed more information about its provenance. It established that the over-paint was added a minimum of thirty years after the death of the Prince in November of 1612. Consequently, it was concluded that the over-paint was not historically important and it was added in an effort to "improve" the painting. Because the underlying paint surface proved to be in



FIGURE 1. ROBERT PEAKE THE ELDER: HENRY PRINCE OF WALES ON HORSEBACK, C. 1610–12, BEFORE RESTORATION. OIL ON CANVAS, 231 × 219.5 CM. ©PARHAM PARK.

good condition, a decision was made to proceed with the restoration. Upon cleaning, five different restorations to repair damages and cover the loss of paint were detected. On completion, the elegant horse with the flowing mane was transformed to a white sturdy tilting horse. Behind the Prince was a naked winged man resembling Father Time carrying the Prince's lance and helmet with a luxuriant colored plume. The plaque bearing the insignia of the Prince now appears on a brick wall behind the Prince and beyond the wall is a garden, which is described as similar to the Prince's garden at Richmond Palace (Figure 2).

To improve the visual aesthetic effects restorers sometimes used materials without experimentally testing them, causing further deterioration of the artifact in the long run. Such was the case in the previous restoration of the Sistine Chapel. Seeping water



FIGURE 2. HENRY PRINCE OF WALES ON HORSEBACK, AFTER RESTORATION. ©THE HAMILTON KERR INSTITUTE.

and humidity caused the pigments of the fresco paint to flake. Animal glue was used by restorers to fix the pigments and to replenish some luster that had been lost due to the salt deposits (efflorescence) on the surface of Michelangelo's frescoes. In addition to hundreds of years of soot and grime, the glue had darkened and yellowed muting the bright fresco colors. Moreover, the glue lost its elasticity with time; it hardened and cracked causing the pigments to flake. All of this conspired to show Michelangelo as an expert in painting the human figure, but a dull colorist. Furthermore, he was accused of not being trained in the school tradition of fresco painting [27]. The latest restoration (1980–1994), undertaken by the Vatican Museums and performed by Fabrizio Mancinelli, Gianluigi Colalucci, and several other conservators and conservation scientists, vindicated him and portrayed him as both a master of colors

and of pure orthodox methods [27–29]. The defense of Michelangelo's reputation is better understood by explaining the chemical composition of fresco painting. The pigment is mixed with water and applied on fresh lime (calcium hydroxide) mixed with sand. The lime reacts with the carbon dioxide in the air and forms calcium carbonate (marble). The shiny surface is formed on drying, and seals the pigment in the plaster. The painter has to be efficient and quick, for this method allows no transgressions or second thoughts. Only rarely was it found that Michelangelo repainted *a-secco* (dry plaster) to add minor retouching.

Art historians, artists, and scientists joined efforts to ensure that the restoration techniques used on the frescoes were justified and that the chemicals used were mild. The cleaning medium used was a solution, AB-57, which has been known for over twenty years. It is made of distilled water containing ammonium bicarbonate ($(\text{NH}_4)\text{HCO}_3$), sodium bicarbonate (NaHCO_3), Desogen (a surfactant and antibacterial agent), and carboxymethylcellulose (a thixotropic agent) [28, 29]. The mixture was applied for three minutes, then was washed with distilled water and left to dry for twenty four hours. Treatment was repeated as needed; however, continuous sampling and analytical testing of the cleaning solutions were performed to ensure that no pigments were washed out during the application. Moreover, cross-sectional analysis proved that, in addition to the grime and soot at the surface, the glue surface also had layers of dust and soot trapped beneath it, which suggests that the glue was added to the frescoes at a later time. A few art historians argue that Michelangelo himself added the animal glue to bestow some shades and tones that would give his figures more depth and color contrast. For them the restoration of the frescoes removed a touch that will forever be lost [29, 30].

Although modern conservation is executed by skilled artists, it combines art with science and goes a step further than restoration by exercising preventive measures to stop future decay [21, 31]. A much larger variety of materials can now be used for conservation, especially with the production of synthetic resins used as adhesives or varnishes with tailored physical and chemical properties. Though modern conservation does not go by a unified code, it is governed by a set of rules [6, 21].

- a) New materials should be scientifically tested before application to ensure that no permanent harm is done to the artifact; and any procedure done should be reversible.

- b) The “six-inches six-feet” rule should be followed. Any damage repair should be discernible to an observer six inches away but not six feet away. The restorer should try to blend or tone with the original but not exactly match it.
- c) The identity, the original intent, and the style of the original composition should be respected. No improvements should be added to the original work.
- d) Restorations on artifacts should be documented.

Conservation is a process that requires the connoisseur art historian and his keen sense of what artistically and historically looks right combined with the talent, taste, and experience of the conservator and the expertise of the scientist. Systematic analysis based on scientific results and the knowledgeable judgments of the people involved dictate the route to follow in the restoration process. When in doubt as to what to do, and the situation does not need immediate intervention, conservators prefer to wait, hoping that future research or findings might bring forth a better solution.

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