THE CARE AND HANDLING OF ART OBJECTS

PRACTICES IN THE METROPOLITAN MUSEUM OF ART

The Care and Handling of Art Objects: Practices in The Metropolitan Museum of Art

Marjorie Shelley, Editor

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PREFACE: ART HANDLING—A FEW GUIDELINES

Marjorie Shelley

One of the Metropolitan Museum's central responsibilities is to ensure that its objects are handled, displayed, stored, and transported employing the best practices and under optimal environmental conditions. Among these critical procedures, hands-on contact with works of art is fundamental to the majority of the actions that are carried out in fulfilling this important mission. Handling objects must be approached thoughtfully and with caution. The diversity of materials within one collection and their varied physical characteristics require that proven handling practices are followed. In addition, unrelenting attention and good judgment informed by experience and knowledge of the physical characteristics of the objects held by the curatorial department are essential.

A significant amount of damage can occur as a result of improper handling, thus ongoing instruction in handling techniques, working alongside conservators and experienced technicians to learn correct PRESERVATION procedures, and asking for help from these individuals to determine the best course of action provide invaluable training in COLLECTIONS CARE. For treasured, irreplaceable works of art and artifacts there is no margin of error. To safely carry out a handling procedure, it is *essential to examine the particular object*. Time must be taken to study its materials, conformation, weight distribution, and points of weakness and repairs, and to confer with the specialist conservator as to the properties of the materials and their environmental requirements. Additionally, *all steps of a procedure must be determined in advance*, whether this be having the right materials at hand for supporting an object for study, anticipating the amount of time needed to accomplish a task safely, troubleshooting the problems that might be encountered in transporting a fragile object, evaluating the safety of a storage location, or any other circumstance that presents itself. While each facet of collections care is of great importance, art handling is among the highest priorities because of its immediacy, its impact on many other procedures, and the unequivocal necessity of doing it right.

NOTE TO THE READER

Words set in SMALL CAPS, including most trademark words mentioned in this manual, may be found in the glossary.

INTRODUCTION

Marjorie Shelley

For several decades, *The Care and Handling of Art Objects: Practices in The Metropolitan Museum of Art* has served as a valuable PRESERVATION manual. While its basic guidelines continue to reflect tried and true practices in this institution, the growth and diversity of our encyclopedic collection, the insights provoked by gallery and storage renovations, and our increasingly dynamic exhibition, loan, and teaching programs—all of which require active handling of artworks—demanded that updated information be made available.

In this revised and expanded edition of the manual, many of the Met's specialist conservators describe preservation strategies employed to best care for works of art. In addition to types of objects that were previously covered, such as paintings, drawings, and textiles, others that have augmented the Metropolitan Museum's holdings in more recent times are discussed, such as photographs and lacquerware, and objects that have long been in the collection are newly addressed: among them, ethnographic works of art, musical instruments, glass and ceramics, furniture and decorative arts made of wood and synthetic materials, upholstered objects, ivory, and books. Revision of the previous edition of *Care and Handling* was also necessary because of our heightened attention to COLLECTIONS CARE: management and procedures aimed at the preservation of museum collections by employing practices that reduce risk and the need for conservation treatment. This two-pronged approach entails controlling environmental conditions—RELATIVE HUMIDITY and temperature, LIGHTING, air quality, and biological activity; and the use of appropriate materials and methods for display and storage as a means of limiting climate and contact-induced damage. These new preservation concepts and practices have been accompanied by new tools and technology for implementing and monitoring these parameters. Additionally, there has been enormous development in the quality and range of housing materials, and this information is now presented in the text and in an updated glossary.

One of the goals of this manual is to make the complexities of caring for a collection readily accessible by presenting information on handling, display, storage, and transport in a straightforward manner. Its emphasis is on preservation—maintaining the object under the best possible conditions at all times, and employing sound practices that will prolong its life and avoid interventive treatment.

Concise explanations are presented on the materials and structure of different types of artworks; the agents that will hasten their destruction; the physical changes to which they are subject under adverse circumstances including contact with inappropriate materials; and guidelines for their handling, display, storage, and transit within the museum. This information makes evident how preservation relies on every physical aspect of the museum—the building, its climate control system, its lighting, and its cleanliness—and, primarily, on the actions of the staff. Its aim can be said to be risk assessment: making the custodians of artworks aware of the constituents of these objects and the hazards to which they are subject. With this basic knowledge, informed decisions can be made in carrying out responsibilities, whether this be determining a safe means of supporting a glass vessel for transport, opening a Japanese handscroll, using gloves or bare hands, employing appropriate housing materials, or dimming the lights in a storeroom.

The first part of this manual addresses fundamental issues pertinent to the diverse works of art in the collection. These chapters have been written by Metropolitan

Museum conservators who are experts in a particular type of material or oversee a curatorial collection. They are organized here as they are in the Museum, according to the responsibilities of either a specialist or a particular conservation department. Some focus on similar types of materials, such as metals, lacquerware, or photography, others on a category of objects such as sculpture or furniture that encompass diverse materials, or on a curatorial collection with a vast array of materials, such as musical instruments, arms and armor, or ethnographic objects. Although some materials are readily categorized as INORGANIC and others ORGANIC, it must be kept in mind that innumerable works of art are composites of diverse constituents, for example, core and ancillary materials, surface coatings, paint layers, attachments or repairs and ADHESIVES, and each aspect must be considered in the object's overall care. Thus, to gain a more comprehensive understanding of the preservation requirements of a particular object comprised of several materials, the reader is encouraged to consult several chapters in this guidebook.

In the second part of this manual, various aspects of collections care are addressed that are directed toward ensuring the safety of the collection as a whole. These chapters, most of which are new additions to *Care and Handling*, are written by conservators, scientists, collection care managers, and staff responsible for registrarial procedures. Of foremost importance are chapters on biological degradation and pest management, the practicalities of safely transporting art within the museum, and emergency preparedness—protocols that are now regarded as vital components in preserving a collection. Information presented in previous editions of this manual but now updated includes guidelines to ensure the safety of objects entering and leaving the collection, and safety standards for works that are to be loaned. Also newly addressed are the technological changes that have occurred in the photography of artworks—a procedure that remains crucial to all collections for documentation, research, and publication—and that have reduced such hazards as exposure to heat and light. This section of the manual also compiles critical information on environmental parameters: temperature, relative humidity (RH), and lighting, summarized in a chart that presents target levels for the many different types of artwork found in the Met's collection. Another chart summarizes information presented in the text on the hazards provoked by unstable conditions and housing. To facilitate use of the manual, a greatly expanded glossary includes preservation terms and concepts, from ACIDITY and BUFFERS to MICROCLIMATES and PLASTICS, and provides important information on monitoring equipment, materials, and commercial products for storage and display. (Glossary terms and concepts cited in the text are indicated in SMALL CAPS.)

Despite the range of information covered in this manual, it makes no claim to being exhaustive and should serve as a point of departure for further investigation. Most chapters, therefore, conclude with a brief reading list, but because preservation and product literature is frequently updated, these references and the information in the glossary should be regularly supplemented with internet resources.

Care and Handling is addressed to all persons who have direct contact with works of art: curators, technicians, interns, museum scientists, collection care managers, future museum professionals, students, and private collectors, and not least to those in small museums and historic houses. Their interaction with objects may range from gallery installation, maintenance of storerooms, exhibition preparation, study-room supervision, photography, and condition checks to transporting works of art within the museum, or research and study. Ensuring the safety of artworks for future generations relies on following recommended handling procedures, and having a comprehensive understanding of their materials, structure, and the environmental conditions that best serve their preservation.

1. METALS

Ellen Howe and Linda Borsch

Most works of art made of metal were intentionally fabricated from mixtures of stable minerals, mined from naturally occurring deposits, and altered by complex processes that often involved heating to very high temperatures. Metals are inherently unstable materials. The process of deterioration begins immediately after manufacture upon exposure to moisture and atmospheric chemicals. This initiates a process of reactions that, through oxidation or CORROSION, convert metals into more stable mineral compounds.

ENVIRONMENTAL CONSIDERATIONS

The role of RELATIVE HUMIDITY (RH) in the deterioration process of metal is critical. Most forms of corrosion are accelerated in the presence of moisture, and therefore objects, particularly archaeological metals, should be displayed and stored in dry, stable environments. A level of 40–50%RH is considered suitable for most works made entirely of metal. Moderate to high levels of relative humidity can be particularly dangerous when SALTS and ORGANIC acids are present, as these conditions will promote especially destructive forms of corrosion. One of them, "BRONZE DISEASE," is characteristic of archaeological copper and copper alloys that have been buried in saline environments, and is identifiable by a pale blue-green powdery corrosion product. Volatile ACIDS—emitted from WOOD and wood products, some ADHESIVES, paints, and other case and storage materials—can also cause severe corrosion in metals, with reaction rates proceeding much more rapidly in conditions of high relative humidity. Objects with bronze disease or other signs of active corrosion should be examined by a conservator.

Inherent reactivity, salts, atmospheric gases

Metal objects will react to unfavorable conditions to differing degrees in a museum setting depending upon their composition, manufacture, and state of preservation. The most reactive metals are zinc, iron, tin, lead, and copper; the least reactive are gold, platinum, and silver. The alloying of metals (the mixing of two or more metals or, in some cases, the mixing of a metal and another element) can result in a product with improved corrosion resistance or increased susceptibility to corrosion. Because metal objects can react with materials in their storage or display environment, to prevent degradation they should not be in physical contact with metal shelving or other metal objects.

A clean, air-conditioned environment is essential for good PRESERVATION practices. Poor atmospheric conditions and pollutants found indoors and outdoors are critical factors in degradation: among them, sulfurous gases from fuel emissions and other sources; volatile acids and alkalis emitted from wood and SYNTHETIC products; and dust, the particles of which serve to hold moisture and pollutants onto metal surfaces.

Relative humidity (RH), temperature, and light

Iron and steel are susceptible to active corrosion in conditions of high relative humidity, especially if contaminated with salts from burial or treatment. Lead and lead alloys such as historic pewter are easily and severely attacked by VOLATILE ORGANIC ACIDS. Silver, silver alloys, and some gold-silver alloys develop surface TARNISH when exposed to sulfurous gases. Copper and its alloys are susceptible to corrosion from ammonia, acids, strong alkalis, chlorides, and gases containing reduced sulfur.

Temperature also plays a significant role in the deterioration of many metals but mainly because of its direct effect on relative humidity. A sudden drop in temperature can raise the ambient relative humidity, causing water vapor to condense on or inside a metal object, thus accelerating rates of corrosion. Fluctuating temperatures can damage objects with unstable joins or cracks and individual components (including metal inlays, solders, pins, screws, and armatures) that tend to expand and contract on heating and cooling. Therefore, temperature levels should be kept as stable as possible.

Composite objects can be extremely sensitive to an unstable environment. Temperature fluctuations can subject painted or enameled metalwork to cracking, FLAKING, and loss of presumably dimensionally stable paints or inlays. Metal objects containing ORGANIC materials, such as wood, ivory, shell, pearl, fiber, organic dyes, pigments, and adhesives, are vulnerable to fluctuations in temperature and RH and are particularly sensitive to degradation from ULTRAVIOLET (UV) exposure. These conditions can cause the breakdown and softening of organic components, such as waxes or resins, creating a sticky surface that can trap acidic and abrasive dust particles.

Gemstones incorporated in metal objects are also damaged by unfavorable conditions: prolonged UV exposure will cause fading of some, such as amethyst, carnelian, citrine, and rose quartz. Others, such as malachite, opal, and peridot, are susceptible to cracking with sudden changes in temperature.

Metals, by themselves, are not particularly LIGHT-sensitive. However, if they are combined or exhibited with other more reactive materials, their lighting restrictions should be considered for exhibition and storage.

HANDLING

Gloves

Metal works of art should be handled with GLOVES at all times, with no exceptions. When an object is handled with bare hands, salts and oils from fingerprints can slowly etch into the structure of the metal surface, causing irreversible damage over time. These disfiguring fingerprints can appear on both PATINATED and brightly polished surfaces. They are permanent and cannot be removed. If an object has been handled with dirty gloves or with bare hands and there are concerns about transferred soils or fingerprints, a conservator should be contacted to examine the surface and determine the appropriate treatment.

Disposable, powderless NITRILE or LATEX gloves, which are meant to be worn once and discarded, are generally recommended for handling metal objects. They are available in a range of sizes and conform well to hands, providing a sensitive, secure grip for objects of all sizes, from tiny pieces of jewelry to large, heavy sculptures. Nitrile gloves are more elastic than other synthetic gloves, resulting in less fatigue with long-term use. An objects conservator should be consulted when choosing a supplier since the quality of the commercially available gloves varies.

Cotton gloves are not generally recommended, as they provide a less secure grip, particularly when lifting smooth or heavy objects. They also tend to be reused

repeatedly without washing, which means that, unlike disposable gloves, they do not protect objects from skin oils, salts, and transferred dirt. In addition, the threads in cotton gloves can snag on protruding metal elements, delicate foils, granules, wires, and settings, causing damage and loss of metal components, enamels, inlays, and appliqués. Cotton gloves with PLASTIC (PVC) dot grips are also not recommended, as they can cause chloride corrosion to form on polished metal surfaces.

Lifting

When handling a metal object, never lift it by its projecting elements, such as handles, spouts, rims, arms, or feet. These sites are potentially weak and can be readily damaged. Rather, objects should be lifted with both hands, always using one hand to support the object from below and the other at the side or top. An object should not be slid or dragged across any surface, no matter how soft it may appear to be. Very fragile objects should only be handled by or in consultation with a conservator.

Examination

Before handling a metal object, it should be carefully examined to determine its overall stability and to identify component parts, including loose or fragile sections. One should be aware that an apparently robust object can be structurally weak and prone to damage. In particular, archaeological metals, which were subject to adverse conditions when buried, are usually brittle from corrosion. Many ancient metals are inherently brittle as a result of their alloy composition. For instance, mirrors from China and Etruscan Italy were manufactured using a high tin bronze alloy that allowed great reflectivity upon polishing but little resistance to mechanical stress. When handled carelessly, these mirrors can shatter. The fragility of some ancient metals has also been aggravated as a result of chemical treatments used in the past to remove corrosion products.

Metal objects made up of numerous elements joined mechanically or with solder are often inherently unstable, especially if they were previously damaged and repaired. Many metals comprising historic and archaeological art objects, notably gold, silver, lead, tin, and pure copper, are quite soft and can be easily scratched or dented. Wood, plastic, or even dust can abrade their surfaces, and, in some cases, fingertip pressure can cause damage. It is important to study surfaces carefully, as some finishing techniques common in fabrication, such as plating, chasing, or burnishing, are capable of disguising cracks, casting porosity, losses, or joins. Similarly, surface enrichment treatments such as acid pickling or depletion gilding can hide underlying weakness.

STORAGE

Materials for examination, transport, and storage

All surfaces on which an object will be placed, even temporarily, should be padded with ACID-FREE tissue or BLOTTER paper, NALGENE®, or POLYETHYLENE foam. Areas of weakness should be padded and stabilized with acid-free TISSUE and polyethylene supports to prevent damage to the object. Whenever possible, objects should be placed in a padded tray or other suitable container, preferably made of polyethylene, allowing the container, not the work of art, to be handled. Objects to be moved should be well

padded to prevent rolling or tipping and transported in a rubber-wheeled truck. Heavy objects should be padded with a thick layer of dense FOAM, such as ETHAFOAM® and generally should be handled by more than one person. CARPET PADS should not be used as PADDING material for trucks, carts, and shelves, since the carpet loops tend to collect and hide abrasive materials (such as staples and tacks), and may contain fibers, adhesives, or other materials that could corrode metals. Cotton wool should never be used to pad decorative metal objects, since the fibers can easily snag on rough surfaces or fragile projecting elements.

Dusting and vacuuming

Since dust is hygroscopic, acidic, and abrasive, metal objects should be kept as clean as possible, whether on view or in storage. It is best to reduce dust accumulation through a regular program of VACUUMING storage areas, galleries, and exhibition VITRINES. A soft Japanese hake brush, in conjunction with a low-suction vacuum that has been covered with a fine screen to prevent accidental loss of any loose fragments, may be used for dry-cleaning under the supervision of a conservator. Risks are associated with dusting museum objects. FEATHER DUSTERS and some commercially available electrostatic cloths should be avoided for the majority of metal objects, since they can readily snag in joins and damage protruding elements, fragile metal foils, appliqués, and settings. Feather dusters are not effective because they tend to scatter dust into the air rather than collect it, redepositing it on surrounding objects.

To reduce dust accumulation in storage, objects housed on open shelving can be loosely draped with acid-free tissue. Polyethylene PLASTIC SHEETING or MYLAR® are safe plastics for storing or draping metals, but an INTERLEAVING layer of UNBUFFERED, acid-free tissue should be used to prevent condensation from collecting on the object. In general, metal objects should not be stored in PLASTIC BAGS except on a short-term basis. If bags are used, they should be pierced to allow ventilation or contain dry SILICA GEL packets to keep the RH low, but the packets must not come in contact with the object.

Housing and air-quality control in storage and display

The ideal storage and display conditions for an object composed wholly of metal are dry, closed environments free of pollutants in gaseous, liquid, or solid form. Various measures can be taken to achieve this.

For housing: Polyethylene storage boxes padded with acid-free tissue or polyethylene foam, and display cases manufactured from conservation-approved materials such as GLASS and epoxy-POWDER-COATED steel, are recommended.

Wood and all wood composition boards should be avoided in order to preclude the emission of formaldehyde and organic acids. Any wood or wood product used for storage or display cabinetry should be completely sealed with conservation-approved paints, varnishes, or BARRIER films such as MARVELSEAL®. Sources of sulfur, such as wool and natural RUBBER products (rubber bands, rubber gaskets, carpet pads, and rubberized fabrics, as well as some paints), should be eliminated from storage and exhibition environments.

All other vitrine and storage materials, including paints, fabrics (especially those using fabric dyes and finishes), caulking compounds, other types of gaskets and

sealants, glues, and certain plastics, should be ODDY-TESTED in order to avoid creating corrosive environments. This entails sealing a small sample of each material with small strips of lead, silver, and copper in a warm, wet environment, and visually recording the degree of corrosion that has occurred on the strips over a one-month period. This simple procedure will determine the safety of any museum display material.

For air quality: Desiccating agents such as dry silica gel and pollution SCAVENGERS such as ACTIVATED CHARCOAL (both available in a variety of forms) can be included in hidden trays or porous sleeves as long as these materials are not in direct contact with objects. Since many metal objects are on open display, in open storage, or in mixed-media vitrines, and the objects themselves can contain other RH-sensitive components, the use of very dry silica gel to control humidity is not always effective or advisable.

Activated charcoal or PACIFIC SILVERCLOTH®, which act as sulfur scavengers, are generally advised for closed storage of sulfide-sensitive materials such as silver, silver gilt, and copper and its alloys, always with an interleaving layer of unbuffered, acid-free tissue. For unlacquered silver on display, a relatively inexpensive active air-filtration system can be installed, which includes a hidden pump that circulates the air in the vitrine through an ACTIVATED CARBON filter. Some objects, especially fragile archaeological metals, may be coated with a clear nitrocellulose lacquer to minimize exposure to AIRBORNE pollutants. Historic silver objects can also be lacquered to reduce tarnishing and the need for frequent polishing.

RH indicators ranging from simple paper strips to sophisticated monitoring devices such as computer data-loggers can be included in storage boxes or exhibition cases to monitor the effectiveness of RH control (see HUMIDITY METERS). Maintenance of these active and passive RH-control and air-cleaning systems is simple and involves replacing charcoal, silica gel, and Pacific Silvercloth® once they are depleted.

All objects, in storage and display, particularly sensitive composite objects such as enameled metalwork, should be protected from extreme fluctuation in temperature by removing potential sources of damaging heat, such as light ballasts inside vitrines, direct sunlight, and spotlights. Objects containing organic materials should be protected from high UV exposure. Because of the great variety of materials and their respective condition, an objects conservator should be consulted to determine the best material for individual storage or display conditions.

Suggested Reading

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2. CERAMICS AND GLASS

Drew Anderson, Lisa Pilosi, and Wendy Walker

ENVIRONMENTAL CONSIDERATIONS

Relative humidity (RH)

In general, ceramics and glass are stable materials. The principal environmental factor for storage and display affecting these objects is atmospheric moisture, therefore controlled RELATIVE HUMIDITY (RH) is the most important consideration in assuring their stability. Ideal levels are 45%±5%RH, 70°±2°F. For mixed-media groupings, 50%±5%RH is acceptable.

Some categories of ceramics and glass are especially sensitive, and unfavorable conditions may result in physical and chemical changes. Unfired or underfired clay is vulnerable to physical damage; it is also water-soluble and unstable. Porous ceramics may be suffused with soluble SALTS as a result of burial in a saline environment or past conservation treatments. This makes them especially reactive to changes in humidity, causing cycles of recrystallization and redissolution of salts within the clay body. If such crystallization occurs just beneath a dense glazed surface, FLAKING or losses may occur. Cold-painted (i.e., unfired) or gilded decoration on glass or ceramic objects is easily scratched or rubbed off. Decoration (such as vitreous paint or enamel) that has been improperly fired and is insufficiently fused to the substrate and/or unusually porous is vulnerable to physical damage and may trap moisture, causing chemical damage.

Some types of glass and enamel have inherently unstable compositions owing to insufficient stabilizing components in their formulation. Consequently, they are adversely affected by atmospheric water, which will dissolve alkaline components in the glass and produce an alkaline solution on the surface. Glasses on which this is present are said to be "WEEPING." Under drier conditions, if the weeping solution evaporates, the salts may be deposited on the glass, which may then become "CRIZZLED," exhibiting a network of fine cracks with a BLANCHED surface. It is not the deposition of the salts that causes the glass to crizzle, but the drier conditions. To stabilize these and other especially vulnerable objects, display in a MICROCLIMATE may be required. Extremely high RH can lead to biological attack on all types of ceramics and glass (see Chapter 20 for a discussion of pest management).

Temperature

Temperature is another important environmental factor for ceramics and glass, particularly as it directly affects RH. Thermal shock from extreme or sudden temperature changes can cause breakage, cracking, or loss of glaze, therefore stability is essential. Stained-glass windows that are displayed in an architectural setting must be shielded from outside weather conditions with protective GLAZING. This sealed, preferably double-glazed window should be installed outside at an appropriate distance. The historic window must have space for ventilation above and below. Monitoring is still important, for even the best protective glazing cannot prevent a certain amount of condensation from forming on the inside surface of the protective glazing on an extremely cold winter night.

Light

In general, LIGHT does not directly affect ceramics or glass, although it can be detrimental to cold-painted surface decoration. Glasses to which manganese oxide has been added as a “decolorizer” to counter the green hue of naturally occurring iron oxides can become solarized, developing a purplish color as a result of prolonged ULTRAVIOLET (UV) exposure. For this reason, glass should not be displayed in strong sunlight without proper UV filters. Light can also adversely affect conservation materials, such as epoxies and paints that might have been used in treatments.

Acceptable light levels for ceramic and glass objects must be determined on a case by case basis. Light is of particular concern where it may cause temperatures to rise and humidity to drop in enclosed areas, such as in a VITRINE or behind a stained-glass panel illuminated by a light box. In these instances, cooler sources of light should be used or ventilation provided to minimize heat buildup.

HANDLING

Before handling objects, it is essential that there be no distractions in the environment and that all persons involved are able to concentrate on the task at hand. One should remove loose clothing, dangling ID cards, and jewelry that could knock against or scratch surfaces.

The use of GLOVES for handling ceramics and glass will depend upon the condition of the object. Cotton gloves may heighten the risk of slippage or diminish tactility and dexterity, and fibers may catch on small protrusions. LATEX or NITRILE gloves provide a better grip, but can likewise pull flakes from rough and physically unstable surfaces of deteriorated glass and ceramics. RUBBERIZED grip dots on some gloves may abrade fragile surfaces. For delicate works of art, it is generally preferable to work with clean, lotion-free, and dry bare hands.

Latex or nitrile gloves should be used when handling ceramic and glass objects with metal attachments that are vulnerable to CORROSION, objects with a porous surface (such as unglazed earthenware or etched glass), or objects with surfaces readily prone to fingerprints, especially when handling these areas is unavoidable. Touching the lead network of a stained-glass window without gloves carries no health risks so long as bare hands are washed immediately afterwards.

Objects must be carefully examined on a clean, spacious table with a soft covering, such as NALGENE®, before handling them. One should note the condition of the object’s surface; for example, those with fugitive pigments should be minimally handled and in undecorated areas, others with rough surfaces are vulnerable to snagging by fibrous materials. Loose fragments or joins and previously restored areas should be noted—for example, a large plaster rim, a handle on a ceramic vase, or a paper fill on a glass vessel—as these are often the most vulnerable areas of the object. If fragments vibrate as a result of a weakened ADHESIVE, do not use masking TAPE to secure them, as tape will damage the surface. In this case, a conservator should secure the vessel before it is moved. Objects consisting of separate components should be dismantled. Lids, goblet covers, stands, stoppers, and mounts should be set aside and handled as separate pieces.

Fig. 1 An object should always be lifted and firmly supported with both hands, usually with one hand at or near the base, the other on the side to steady it.

An object should always be lifted and firmly supported with both hands, being aware of its center of gravity. The shape of the piece will determine where the hands are placed, but in general one hand at or near the base, the other at an appropriate place on the side to steady it **(Fig. 1)**. An object should never be lifted by its handles, spout, knobs, or rim, as these areas are structurally relatively weak. Flaking surfaces or paint layers should not be touched; instead, when possible, the object should be handled on its secure undecorated areas. Objects at risk should be placed in a PADDED tray or box that can be handled instead. Only one object should be handled at a time.

When lifting a large object requires the assistance of several people, a plan should be devised in advance outlining who will direct the operation, how the lifting will proceed, where the object will be placed, who will steady the cart, and other considerations for the procedure. The route should be clear and a space prepared for the object to be deposited.

Large stained-glass windows or framed ceramic tiles should be lifted and carried vertically (see the section on Transport below). Generally, the panel will be relatively safe if it is framed and supported on a rigid board. The object should be lifted by taking hold of a strong area, such as a lead joint that is not broken or otherwise damaged. A specialist conservator should be consulted if there are breaks in the glass, paint losses, or damage to the lead.

STORAGE

Stable environmental conditions are the most important consideration for storage. Relative humidity, temperature, and lighting guidelines noted at the beginning of this chapter must be applied in storage: 45%±5%RH, 70°±2°F are generally acceptable levels. However, ceramics and glass kept in mixed-media groupings can be stored at 50%±5%RH. It may be necessary to store vulnerable objects, especially susceptible glasses, in microclimates. Sensitive glass objects must be protected from high light levels, and ventilation provided to protect from heat buildup in enclosed spaces. Objects should not be placed near doors, passageways, vents, and air ducts, which may contribute to dust accumulation.

Ceramic and glass objects should not be crowded or stacked in storage. Most utilitarian and decorative objects were intended to stand on their own and can be stored this way. Objects with a high center of gravity and a small base may be better stored upside down.

Small and medium-sized objects can be stored on padded shelves to reduce abrasion. The stability, weight, and center of gravity of the object must be considered in determining whether and what type of PADDING should be used. Very small objects and fragments can be stored in padded drawers. Very large objects may need to be stored on the floor in a safe, protected area. Objects should be protected from dust by placing them in closed cabinets or, if in the open, by covering them with a POLYETHYLENE sheet.

Small, flat objects such as mirrors, small stained- or enameled-glass panels (such as silver-stained roundels), and small leaded panels can be stored flat. Unfired reverse-painted glass panels should be stored flat with the painted surface face up. Larger glass panels and leaded panels should be stored vertically, preferably resting on the longer side. Ideally, panels should be stored in racks made with vertical divisions to minimize the risk of buckling, but additional support may be required for panels leaning at a slight angle. Metal racking systems are recommended for storage. If WOOD is used, only material of low ACIDITY is advisable.

TRANSPORT

The same guidelines for handling must be applied to transporting ceramics and glass, always noting any surface fragility, and if gloves are required for handling.

There are several ways to carry and move an object; its size, weight, and shape will determine how it should be transported and securely positioned before moving to another location. Carts with rubber wheels, FOAM-lined boxes, and padded baskets are suitable for small to medium-sized objects; hydraulic lifts, side carts, and dollies of various sizes are appropriate for larger objects.

The same considerations for padding objects while in storage pertain to objects in transit. A group of small objects can be placed in a box or basket as long as there is sufficient padding between them; the objects should be prevented from rolling or jostling against each other while en route. SANDBAGS, foam WEDGES, and ACID-FREE PAPER cushions are useful in securing and protecting objects.

Large objects should have sandbags positioned around the foot and base for stability, and should be further supported by a second person while en route. When this is not possible, the object should be positioned on its side, cushioned with ETHAFOAM® and using sandbags, foam blocks, and/or wedges to support all points of weakness. The object should not rest on any projecting elements, such as handles or decorative

features. Sometimes a very wide-mouthed vessel with a relatively small foot is better transported upside down, as long as inverting it is a safe option.

Stained-glass panels, even if framed, should always be supported on a rigid board when moved. The ideal board for this purpose will have a horizontal ledge along the base and a vertical ledge along the side so that a supporting corner is created. The board may be made of plywood, ACRYLIC SHEETING, FOAMCORE, or other materials as long as they offer support and are inflexible. A CUSHIONING MATERIAL, such as BUBBLE WRAP or Nalgene®, should be placed between the board and the glass, with a layer of ACID-FREE tissue next to the glass. Cushioning is essential for panels with an irregular surface. When moving, the board should be tilted slightly backwards from the vertical position, and the object should be supported throughout the entire process when adjusting to a horizontal position (or vice versa). For large panels, this might require two people, each holding the board and the panel. When a small panel is being removed from a table and no alternative support is available, the table edge can be used for support by holding the panel at the top and at the base, sliding the panel off the table until the midpoint is at the table edge, and angling the panel to the vertical position using the table edge as axis. Particular attention must be paid to any weak points in the window's design; for example, a lead running the entire length of the panel parallel to the edge of the table could cause the panel to fold while being lifted to a vertical position. Finally, resting a window on its corner should be avoided. Too much weight on this small area is guaranteed to risk damaging the panel, especially if it is unframed.

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3. SCULPTURE

Jack Soultanian

ENVIRONMENTAL CONSIDERATIONS

Sculpture may be encountered in various media—both INORGANIC and ORGANIC—and includes works in marble, limestone, alabaster, terracotta, bronze (and other metals), plaster, WOOD, ivory, and wax, among others. These materials have varying environmental requirements and, depending upon the stability of the specific work, these requirements may range from minimal to strictly controlled climate systems.

Undecorated stone, terracotta, and plaster sculptures, in good condition and without internal supports, may be exposed to a relatively broad range of temperature (T) and RELATIVE HUMIDITY (RH) conditions (55–75°F; 35–60%RH). Sculptures that exhibit SALTS, commonly recognizable as white crystals on the object's surface and often, but not exclusively, found on objects that were once buried, may require a specific and stable humidity to keep them in check. For organic media, such as wood and ivory, a narrower humidity range is desirable—generally around 50%—to prevent desiccation, which can result in splitting or cracking. Polychrome sculptures on organic substrates are particularly sensitive to a dry atmosphere and changes in RH, and sudden fluctuations in T and RH may provoke damaging alterations to the object. For example, while a wood substrate may expand and contract with changes in humidity, the paint layers remain more rigid, resulting in tenting or FLAKING of the polychromed surfaces.

Bronze sculptures have quite the opposite requirement from wood: a moderately dry environment (40–45%RH) is suitable for them, while too much humidity may promote CORROSION even in bronzes that have not been excavated. While it is a rare occurrence for an object that has never been buried, such as a Renaissance bronze, to develop BRONZE DISEASE, it may occur when moisture and chlorides are present. This combination of factors will allow for reaction with the copper component of the bronze, resulting in the formation of copper chlorides that appear as bright green powdery spots of corrosion. This phenomenon may be exacerbated if the bronze is gilded, as the close proximity of these two dissimilar metals further encourages this reaction. If active, the bronze should be placed in an atmosphere in which the humidity is below 35%.

Additionally, humidity that is too high—generally above 70%—promotes mold growth on a variety of materials, most often on organic substrates. If any of the above conditions is suspected, or if the object has been in an uncontrolled environment, a conservator should assess the situation and offer recommendations.

Certain sculptures have specific environmental requirements and may be particularly sensitive to RH fluctuations within the standard ranges set by the museum for its galleries and storage areas, or may have an RH requirement different from these established conditions. Such objects, for example stone or terracotta pieces containing salts or those made from organic materials, may require storage or display in a MICROCLIMATIZED case that can be set to a specific, stable RH level through the use of conditioning agents, such as SILICA GEL.

Just as ideal RH levels vary for the diverse sculptural media, so, too, some objects may be safely exposed to relatively high LIGHT levels, whereas others require subdued illumination for their PRESERVATION. For example, unpolychromed sculptures made from inorganic materials, such as stone, terracotta, and plaster, that do not have repairs may be bathed in light without damage to their fabric, but polychromed works and those in wood and ivory, among other organic media, should be kept out of direct

sunlight and at light levels maintained between 15 and 20 FOOT-CANDLES and ULTRAVIOLET-filtered.

Fig. 1 Exit holes in a polychrome wood sculpture.

High levels of humidity may contribute to INSECT INFESTATION of wood sculpture. Woodworm attack is characterized by exit holes **(Fig. 1)** along the surfaces of these objects, and wood powder may often be found at their bases. Exit holes, however, are not necessarily a sign of active woodworm but may simply reflect a previous and no longer threatening attack; the presence of wood powder, or FRASS, may also be from an earlier infestation, having been shaken out of the sculpture from a recent move to a new location or other disruption (see Chapter 20 for a discussion of pest management).

HANDLING AND TRANSPORT

When handling sculpture, clean GLOVES should be worn; hand oils may stain porous sculptural materials such as marble and terracotta, and finger ACIDS can etch metal surfaces. NITRILE gloves are ideal for handling such vulnerable materials. However, if by wearing gloves a firm grip on the sculpture is jeopardized, they may be dispensed with, as the security of the sculpture must always take precedence. In such cases, hands should be washed and thoroughly dried immediately prior to handling.

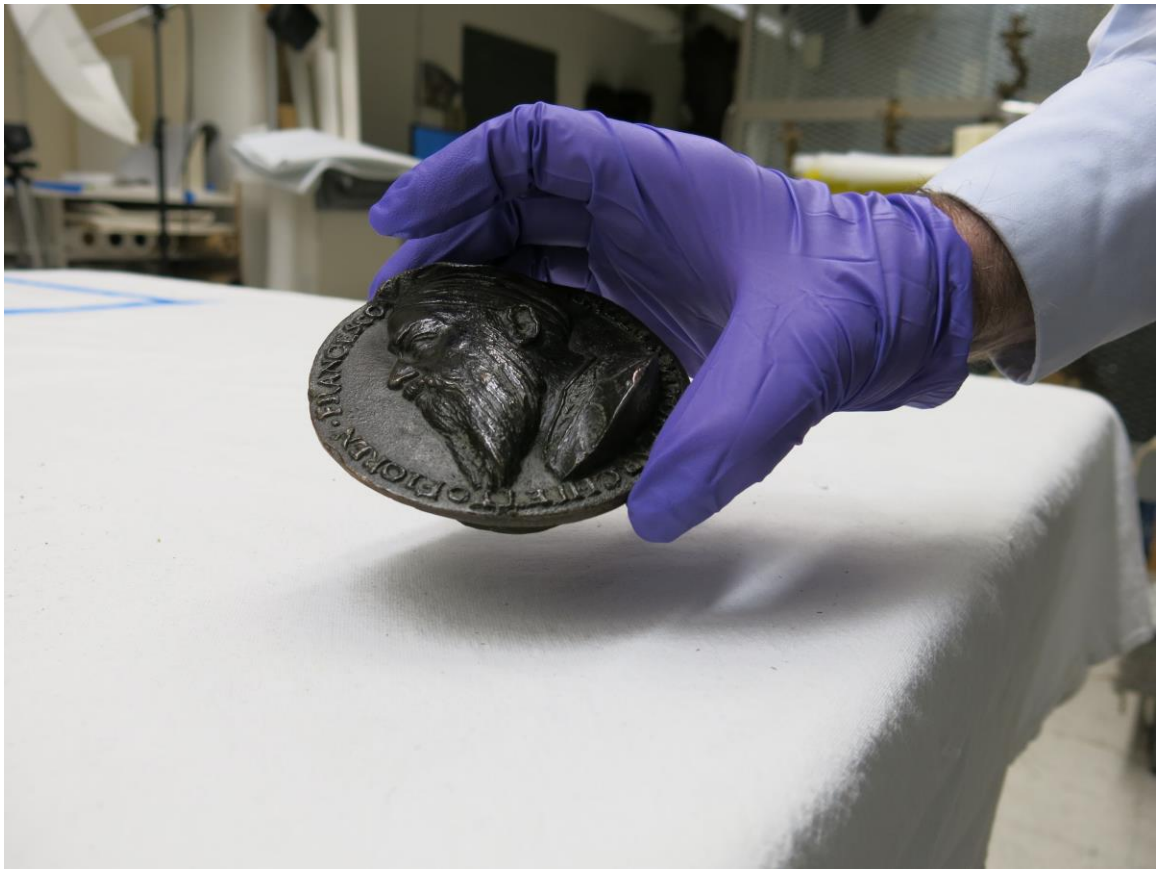

Fig. 2 Lifting a bronze medal by its rim.

While it would often be safest not to move sculpture at all, a move in position and location of these works of art is sometimes necessary. For oversized or extremely heavy sculptures, professional riggers should be enlisted. Otherwise, before handling, the sculpture should be examined to determine points of weakness and areas of damage or repair. A sculpture should never be grasped by its extremities, such as an outstretched limb, but rather handled at its thickest and most solid parts. Medals and plaquettes should be lifted by their rims **(Fig. 2)** and never stacked, as doing so would increase the risk of scratching their surfaces.

Fig. 3 Tilting and lifting a small sculpture in a cart prior to transport.

Whenever possible, a sculpture should be transported in the position in which it is generally viewed. If the sculpture is very small, light-weight, and lacks an auxiliary base, or if it is fixed to the one on which it rests, ideally it should be raised straight up or, if this is not possible, gently tilted back at the base, while being supported with one hand

toward the top of the sculpture and then lifted with the other hand from the underside. The angle of tilt should never be high but rather just sufficient to place a hand beneath the work; otherwise, there is a risk of damage to the edge of the base **(Fig. 3)**. Damage to the base is of particular concern for larger sculptures. In these cases, FOAM sheeting—for example, VOLARA®—may be needed beneath the base edge. Additionally, heavy cloth or PLASTIC SHEETING placed completely underneath the base and extending beyond it may be useful for moving these heavier sculptures. By so doing, the sculpture is then in a position to be drawn forward by pulling on the underlying PADDING rather than the object itself, thereby reducing risk both to the work of art and to the surface it may be resting upon.

Fig. 4 Padding the parts of a sculpture.

If the sculpture is not affixed to its base, and is readily separable from it, the two parts should be disengaged before moving and the sculpture laid down horizontally and any points of weakness supported with padding. Crumpled ACID-FREE tissue for lighter works and SANDBAGS or POLYETHYLENE foam for heavier ones are usually readily available and can easily conform to the often irregular shapes that sculptures present **(Fig. 4)**. Similarly, if a sculpture cannot stand safely on its own and would ordinarily require clips at its base or other support to secure it for display, it may also be placed in a horizontal position for transport provided that its reverse side is flat and undecorated. Otherwise, the sculpture should remain in its vertical position and either padded at its sides or WEDGED at its bottom to avoid shifting during transport.

Small, light-weight sculptures may be put in shallow containers before being placed on transport carts, and, under certain circumstances, these works may be hand-carried in sturdy, padded straw baskets, the security of their handles having been first

carefully checked. Shallow containers are also ideal for examining these smaller works, as the container itself may be turned for viewing the sculpture from several angles, thereby minimizing the handling of the object.

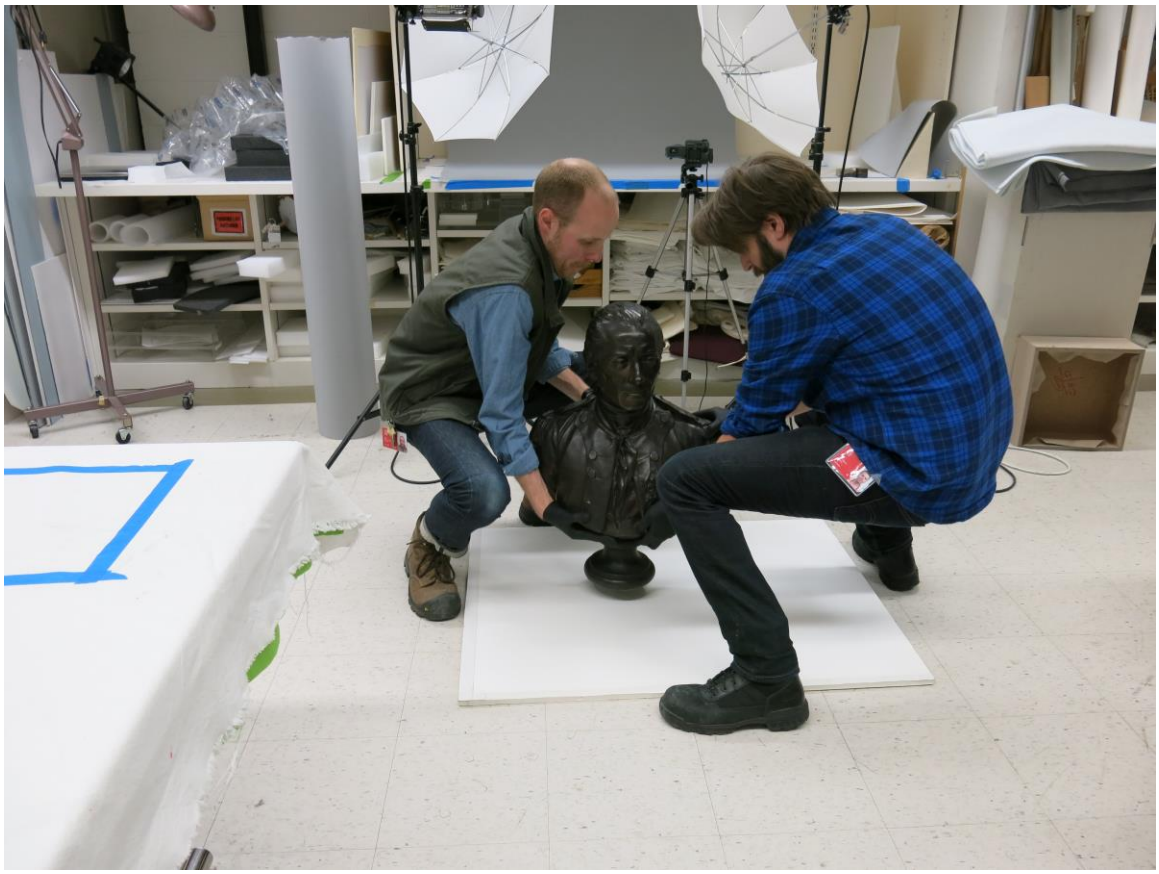

Fig. 5 Lifting a heavy sculpture by bending at the knees.

Fig. 6 Lifting a cart over a threshold.

If the sculpture weighs more than 50 pounds, it should be handled by two or more individuals. The handling procedure should be established by all involved before the work is touched. When lifting a heavy sculpture, one should never bend at the waist, but rather at the knees to support the weight **(Fig. 5)**. Large sculptures should be transported on rubber-wheeled flatbed trucks; reliefs should be placed upright on a side truck and strapped to it with blanketed pads or those made from polyethylene foam, ideally covered with acid-free tissue placed between the sculpture and the ratchet straps. Sculpture is best moved with two people: one to navigate the cart and the other to ensure that the path is clear and to open doors. Carts used for transporting sculpture should never be pushed from behind over a threshold, but rather lifted first from one end over the threshold followed by the other end **(Fig. 6)**.

STORAGE

Fig. 7 Storing sculpture on an open shelving unit protected by clear sheeting.

For storage, sculptures that fit on shelves and are sufficiently light to be supported by the shelves should be protected from dust by placing them in closed cabinets or with

polyethylene plastic sheeting secured in front of open shelving units **(Fig. 7)**; in either instance, the shelves should be covered. The stability, weight, and center of gravity of the object must be considered in determining the type of covering to use. Wrapping and unwrapping of the work should be a consideration for stored collections that are often studied. Wrapping the individual sculpture in acid-free tissue, or comparable INERT opaque material, might minimize dust accumulation; however, it renders the sculpture visually inaccessible and requires unwanted, additional handling. POWDER-COATED METAL is the preferred material for shelving, both for its sturdiness and for its lack of reactivity with sculptural media. WOODS, such as oak, may emit organic acids that can corrode metals, and COMPOSITE WOODS, such as certain plywoods that are manufactured with urea-formaldehyde, can give off formaldehyde gas that is also potentially dangerous.

If sculptures are too large or heavy to be put on shelves or in cabinets, they should never be placed directly on the floor, where they might be kicked or stepped on. Rather, they should be placed on low platforms or pedestals. Dollies are good for this purpose, as they not only raise the sculpture from the floor, but the sculpture may also be easily turned for viewing of all its sides. Depending upon the sculpture's size, shape, and weight, a dolly may also be used for transport, thereby avoiding additional lifting with its related inherent risks. It is important that the wheels of the dolly be locked at all times while in storage.

Accumulated dust on a sculpture may be removed with a soft brush, such as a Japanese hake brush, that is gently passed over the surfaces of the object. For unpolychromed works, a VACUUM nozzle may be placed close to, but not directly on, the object to catch the brushed dust. A vacuum should not be used for a polychrome sculpture, as even seemingly stable paint surfaces may have incipient lifting, and the force of the vacuum may detach these flakes. Similarly, FEATHER DUSTERS should not be used for polychrome works, as the feathers may catch and snag the edge of the paint flakes and pop them off.

Displaying sculptures in cases helps to keep dust off and is particularly important for polychrome sculptures where matte azurite paint layers are present, as these sensitive surfaces are difficult to clean. Storage units and display cases should meet the same criteria as open shelving. Wood ADHESIVES, paints, and varnishes used in their construction should be ODDY-TESTED to avoid potential problems. These dangers may also be present in the fabrics used for the case lining or for covering the sculpture's mounts or decks; thus, these types of materials should similarly be Oddy-tested to determine whether they may cause corrosion to metals, including metal leafs (and in particular, silver leaf), often used in the decoration of polychrome sculpture.

Suggested Reading

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4. ARMS AND ARMOR

Ted Hunter

The collection of the Arms and Armor Department encompasses over 14,000 objects, the majority of which date between ca. A.D. 500 and 1900 and span the major cultures of Europe, North America, the Middle and the Far East. The range of materials is equally varied: ferrous and other metals, wood, bone, horn, steel, paint and lacquer, textile and paper. The diverse holdings include complete and partial armors, helmets, shields of varied materials, edged and staff weapons, archery equipment, firearms, equestrian equipment, civilian and military costumes, coins, medals, and works on paper.

ENVIRONMENTAL CONSIDERATIONS

The care and handling of arms and armor, including environmental conditions, is not different in most cases from any other decorative or ethnographic art, or paper-based material. Temperature and RELATIVE HUMIDITY (RH) levels of 68–72°F and 50%±5%RH are generally recommended in order to minimize the risk of CORROSION of steel objects may be exhibited in the same VITRINE. Fluctuations in RH can be damaging, causing, among other problems, scabbards to shrink or gunstocks to warp. Each object should be evaluated to determine its specific requirements and if a MICROCLIMATE is needed for optimal protection. Because many of the works in this collection are combinations of materials with different requirements, the suitable level of care is generally determined by the most vulnerable component. The advice of a conservator should be sought when in doubt. LIGHTING levels will also depend upon the organic and INORGANIC constituents of the objects, as WOOD, textiles, and paper, for example, will fade and weaken from prolonged exposure to light, especially if ULTRAVIOLET (UV) radiation is present. Protocols on lighting and other environmental considerations can be found in various chapters, charts, and the glossary of this manual describing the component materials of these objects.

HANDLING

Fig. 1 Handling firearms

Fig. 2 Handling firearms

Fig. 3 Handling firearms

Unlike other museum objects, many of these works of art are weapons and may have sharp points or edges, thus caution and common sense should always be applied when they are handled. One should always treat weapons as potentially dangerous: that is, assume edged weapons are sharp, assume a firearm is loaded until proven otherwise, and never point a firearm at another person even when it is known to be empty. **(Figs. 1-3)**

Armors are complex objects composed of many parts and often of very different materials, each of which may be constructed of multiple plates often attached to one another by a combination of metal rivets and leather straps. Many elements, such as helmets, may have moving parts meant to have flexibility. Therefore, to ensure the safe handling of arms and armor, it is imperative to first evaluate the condition of each of the component parts to determine its stability. For example, loose rivets and weak hinges may place additional stresses on remaining parts; broken strapping may offer only partial support to the object; and weakly attached elements and bases of mannequins may fail to provide necessary support. It is equally important to assess the extent of the corrosion of the metal components, and the fragility and brittleness of the leather, wood, and textile attachments. These factors will dictate how the object is handled, stored, and transported as well as its optimal environmental conditions.

Fig. 4 Handling armor

Metal objects should be handled with nitrile GLOVES. Iron and steel are the most common materials for arms and armor, but all metal surfaces, particularly decoration—bluing, gilding, and etching—are easily damaged by skin oils. **(Fig. 4)** To avoid unnecessary handling, small objects should be examined in trays, placed on nonfibrous FOAM cushioning, ACID-FREE PAPER, or RAG BOARD. WEDGES and wads of ACID-FREE tissue can be used for additional support and to separate objects from one another. Fibrous materials should also be handled with NITRILE gloves; cotton gloves (which

should be clean) may snag the object or dislodge parts, and may not offer a firm grip. The handling of large objects requires two or more people.

Trays are useful for examining pistols and longer firearms, especially when parts are being removed for study or conservation. All armor elements, especially those that are flexible, should be supported with padding or wedges, to prevent rolling on a table or shelf. Many armor elements appear to be attached to one another but in fact are held only with keyhole-type posts or potentially weak straps; thus caution should be used when handling an object composed of multiple elements. Some elements, such as internal straps, can be damaged if picked up carelessly. Large objects should be handled by as many people as required to manage their weight and size. The method of handling should be discussed prior to undertaking any move.

Many assessments must be made in handling swords and other edged weapons. Especially for transport, it is prudent to place small blocks of ETHAFOAM® onto pointed elements. The use of cork, though perhaps traditional, is not recommended because it absorbs atmospheric moisture, which may provoke localized corrosion. Additionally, the ACIDS naturally present in cork are a potential source of damage. One should avoid holding these objects by the grip: grips, pommels, and guards are often wobbly and the grip may be fragile and not securely attached to the blade. It is best to carry the blade vertically (when not too sharp to do so), with the hilt up, or on a cart with supports. Blades may be flexible, therefore require ample lateral support.

When removing a scabbard, the weapon must be held vertically; a fragile or broken object could be further damaged if allowed to sag or flex. When drawing a blade from a scabbard, the scabbard should be grasped so as not to accidentally run the blade across one's hand; this could be especially serious with very sharp Japanese blades. Swords kept in their scabbards may be stuck, either from rust or the shrinkage of the casing, or those stored outside the scabbard may be impossible to reinsert. The metal mounts or "furniture" on a scabbard are often loose; care must be taken that they do not detach, and that there is no dirt or debris on the interior that can damage the blade.

For firearms, one should determine if the stock is damaged. Wooden stocks can have cracks and weak areas, among them, the narrow portion just behind the lock or the thin foreshock under the barrel, which could break during packing or transport. Locks, barrels, and metal mounts are attached by screws and small pins that often work loose and thus should be checked. It is critical to determine that the firearm is not loaded. Lock mechanisms are often fragile and subject to breakage and loss. They should not be packed or moved in the cocked position, which puts pressure on an internal spring; firearms should be packed or stored with the lock on the top, not resting on the mechanism.

Fig. 5 Storing armor

A variety of storage methods are used for arms and armor. Compact storage and drawer-based systems made of POWDER-COATED METAL are the most suitable for long-term storage, as they are chemically INERT, limit dust accumulation, and block out light. Drawers should be lined with Ethafoam® that is form-cut and the object covered with PLASTIC SHEETING to prevent dust accumulation while allowing for visibility. Slits should be cut in the sheeting to prevent condensation. **(Ch. 4 - fig. 5)** Firearms of unusual length are difficult to store flat, as are very long swords, and these objects generally require vertical racks. Many items are best stored in commercially available ARCHIVAL boxes and, when the object has an unusual shape, in custom-made rag board boxes.

TRANSPORT WITHIN THE MUSEUM

In transporting small arms and armor, the same considerations come into play as when moving small objects and sculpture, hence appropriately sized padded trays and transport carts should be used. Large, full-length mounted armor on a mannequin should be moved in an upright position on an appropriate transport cart that can support the weight and configuration of the object. It should be determined in advance how many people will be necessary for the operation. Use of a standard mover's dolly will require one person to push or pull the armor and another to stabilize it during transport. To lift a mounted armor, it is necessary to have one person on either side of the object, which is lifted with a strap under the base, while a third person slides the dolly underneath the armor, and one or more persons steady the upper portion. Before lifting or moving mounted armor, one should check the stability of the ankles and any other moving parts of the mannequin. If possible, it is advisable to remove gauntlets and helmets prior to moving an armor. Sudden and unexpected movement or placing stress on weak points should be avoided.

PACKING FOR LOCAL TRANSPORT

It is not necessary to dismount most European armor for travel. If the armor is securely fitted to a mannequin, it may be sufficiently stable to pack as an upright unit. Loose parts that are likely to move during transport should be removed and packed separately, particularly the helmet, gauntlets, and tassets (thigh defenses suspended from the breastplate). Armor should be dismounted if straps or laces are very fragile, but only if additional handling does not present risk. Acid-free TISSUE should be wrapped around all elements to prevent movement, stuffed into hollows to provide support, and fitted between overlapping plates and contact points to prevent abrasion. One or more layers of BUBBLE WRAP should be used depending upon whether the outer wrapping is CARDBOARD or a wood crate, but it should not be in direct contact with the object. Cotton twill STRAPPING TAPE may be used to secure tissue and padding, and to secure these materials to the armor and its mannequin. Armor with extensive textile components, such as those from Japan or China, should be dismounted for travel.

Modern gun cases, made of either PLASTIC or aluminum, are useful for packing firearms and edged weapons. They are hard-sided and lined with thick FOAM. For armor elements, boxes with Ethafoam® cutouts specific to the shape of particular objects offer good protection. Like a complete armor, these individual objects should be wrapped with acid-free tissue and stuffed and fitted with tissue to provide support and prevent abrasion, and, if there is a chance of exposure to high levels of humidity or dust, placed in POLYETHYLENE PLASTIC BAGS. For long-term storage, the bag should have slits to

guard against the development of condensation. When unpacking a firearm and removing any wrapping, care must be taken to avoid accidentally grasping the ramrod. As with storage, firearms should be packed so that they are not resting on the lock.

5. ETHNOGRAPHIC FABRICS AND FIBER-BASED OBJECTS

Christine Giuntini

The ethnographic or world collections in the Department of the Arts of Africa, Oceania, and the Americas at The Metropolitan Museum of Art are primarily drawn from the indigenous cultures of these continents along with the so-called nonimperial cultures of Southeast Asia. Along with flat fabrics, which serve as wrapped clothing, ceremonial cloths, and utility cloths and mats, a great many objects in this category have a textile or plant-fiber component that serves as the armature supporting the other materials added to it. These items include, but are not limited to, head and body masks, headdresses and other body adornments, ritual clothing, and ritual and utilitarian objects. Many types of ethnographic objects, especially those created for ritual purposes, were not made with permanence in mind. Many of the materials are ephemeral and will eventually deteriorate completely; it is our privilege to extend the life of these artifacts with as little impact on the appearance of the object for as long as possible.

ENVIRONMENTAL CONSIDERATIONS

The primary enemies of fabrics and composite fiber objects are uncontrolled LIGHT, temperature/RELATIVE HUMIDITY, pollutants, and biological degradation. The damage caused by these four factors is cumulative and irreversible (see Table 00). Improper handling also may result in damage, but can be avoided by training in appropriate methods.

Light

The recommended exhibition guideline for all textiles is 3–5 FOOT-CANDLES. For large, flat textiles and many types of three-dimensional objects that are displayed for limited time periods, 3–7 foot-candles is permissible.

Temperature (T) and relative humidity (RH)

The recommended temperature for storage and display of fabrics and composite fiber artifacts is within the range of 68–72°F (20°C). Generally, a lower temperature (68°F) is better for ORGANIC materials; however, because fluctuations in T/RH are inevitable, the DEW POINT (the stage at which water vapor condenses to water) must never be crossed. Skins and furs do not require storage in a special cold room. Should cold storage be necessary, these items must be wrapped in several layers of washed cotton MUSLIN or flannel, and covered with POLYETHYLENE sheeting or placed in polyethylene bags. The additional layers of cotton fabric provide insulation to slow the cooling and warming of the object as it is moved from one temperature zone to another. The packaged works should be placed in boxes or on boards to facilitate handling. Such prepared works can then be stored at approximately 10°F below gallery conditions.

The RH range for fabrics and composite fiber artifacts can occasionally move slowly between 55% and 40%, with the ideal RH falling at 50%±5%. This broad range is not, however, recommended for some of their associated materials, such as metals and

glass. In instances when INORGANIC or nontextile components are present (or when organic and inorganic objects are displayed or stored together), lower levels usually take priority over those recommended for organic components. In most cases, environmental conditions will be a compromise favoring the more unstable materials. Finally, attention should be paid to rising humidity levels, as certain kinds of mold will begin to form within a few days if RH rises and remains above 55%.

Pollutants

Gasses and other vapors, along with particulate materials—commonly referred to as dust—are the most common pollutants brought in by visitors and gallery activity. These finely divided particles, which move with thermal-driven air currents, can consist of textile fibers, hair and skin cells, pollen, insect parts, dead microbes, commercial cleaning agents, minerals, and petroleum byproducts, among other materials. They cause damage by initiating chemical reactions on the surfaces of artifacts, and by surface abrasion. Over time, their accumulation results in dark, greasy deposits that can be impossible to remove. Air-filtering systems are effective in minimizing the total volume, but complete eradication is impossible, thus good housekeeping is the primary defense against this cause of deterioration. While small and fragile fiber and fabric objects can be protected by displaying them in sealed VITRINES, this is sometimes not practical for large hangings and composite works of art, thus these objects should be exhibited on BARRIER platforms to minimize their contact with pollutants found in galleries.

Biological agents of deterioration

Mold, insects, and warm-blooded pests such as mice can cause damage to artifacts that will result in holes, tears, and disfigured surfaces, as well as stains from urine, feces, or FRASS. These damaging agents can be kept in check by INTEGRATED PEST MANAGEMENT. These housekeeping guidelines entail regular cleaning of public, administrative, and storage spaces; prohibiting food in these areas; and placing trash in enclosed containers and removing it to designated locations on a daily basis. Additionally, pest-monitoring devices such as GLUE TRAPS should be used and routinely checked to identify the type of pest and determine if further action is necessary. A conservator or pest management expert should be consulted for their appropriate placement.

HANDLING, STORAGE, AND DISPLAY

Handling, storage, and display guidelines for most of the ethnographic fabrics and composite fiber objects in a museum collection follow the same PREVENTATIVE CONSERVATION principles as those given for flat and three-dimensional textiles. Training in these methodologies is key; unintentional damage usually results from not understanding or adhering to these principles. Clean hands or clean cotton or nitrile GLOVES and a clean, stable, and comfortable work surface are the minimum requirements for examining a fabric or composite object *prior* to it being handled or moved. If there is any possibility that an ethnographic work of art has been contaminated with PESTICIDES, NITRILE gloves should be used. Should parts of an object become detached or break spontaneously, even when no movement or handling has occurred,

all loose pieces should be saved and put into a container or POLYETHYLENE storage bag and brought to the attention of the conservator.

ASSESSING THE CONDITION OF ETHNOGRAPHIC WORKS OF ART

All individuals handling ethnographic objects should have training in how to assess the overall condition of a fiber or textile artifact before it is touched, moved, or packed. For objects composed of two or more materials, it is necessary to determine the condition of the various components (refer to the relevant chapters). Technicians and other handlers should be aware of the signs of INSECT INFESTATION, such as cocoons, insect parts, larvae, and frass, as they are common indications of past or present damage to these artifacts.

For *flat or three-dimensional fabrics with no or few attachments*, all surfaces, including the area around and just under the edges of the artwork, should be visually examined before handling. Powdered or broken fibers indicate that the fabric is in a compromised condition. This is often the case with archaeological textiles as a result of great age and former function, but degraded fibers are also found in fabrics suffering from adverse environmental conditions or INHERENT VICE, which is the auto-deterioration of their constituent material. Changes in color or surface texture are also indications of deterioration. Very damaged and denatured textile and plant fibers are usually darkened. Tears, holes, losses, and other damages to the overall structure are also indications of poor condition. If there is any uncertainty about how to handle a fabric, a conservator should be consulted.

Composite fabric-fiber objects comprise an almost limitless range of associated materials and therefore require more time to determine condition before handling. They include inorganic materials such as metal, stone, glass, and clay/ceramic materials; organic materials, which include but are not limited to wood and other plant materials (seeds, leaves, pods, bark, roots); shell, bone, antler, and ivory; and claws, carapaces, feathers, horn and hair, skin and leather. Each of these materials can range from minimally to highly processed.

The first step in assessing these objects is to determine the condition of the *foundation fabric or fiber structure* and if it adequately supports its own weight and the materials added to it. The same procedure described above can be followed. It is, however, often not possible to examine all the internal parts of these objects. Consequently, it may be necessary to touch, slightly move, or otherwise feel an object to gain an idea about its condition. If the object is more than 9–10 inches tall, or if it is evident that the base is smaller than the top, it is imperative to estimate its center of gravity in order that it be properly braced before moved.

The second step is to assess the condition of the *attaching strings, yarns, or other fibers* that secure the added materials to the textile foundation. A wide variety of plant and animal materials are used for this purpose, and the resulting strings or fibers can range from minimally to highly processed. Weaknesses in attachment fibers can lead to breaks and losses when the fabric is moved or handled. It is usually not possible to examine each individual attachment, and often the fibers are hidden, as is the case with beading strings; therefore the art handler must look carefully and appropriately support the entire object when it is moved.

Finally, the condition of the attachments should be assessed. The reader is referred to those chapters on glass, metal, wood, etc., to learn about the care and handling of these materials. Below is a compilation of some commonly occurring attachments encountered and the type of deterioration to which they are most prone.

Compromised objects tend to be powdery, friable, or fragile, therefore direct handling should be avoided; instead, such objects should be manipulated and moved with the aid of a sturdy support. If fragments are actively falling away from an artifact, or when other signs of deterioration described below are detected, a conservator should be consulted before the object is moved.

- *Beads* are made from many materials—stone, mineral, shell, bone, ivory, and metal (including coins)—but most commonly they are glass. Beads are usually attached to a textile or fibrous substrate by strings of plant or animal origin, but can also be physically embedded into other types of surfaces. Symptoms of diseased or "WEEPING" glass, which is commonly encountered, include internal occlusions and fractures, a milky opacity, a "cottony" EFFLORESCENCE or a wet soapiness, breaks, or a tendency to crumble.
- *Feathers* are formed from a type of keratin. They are commonly attached to textile/fiber artifacts by stitching or adhesives. New feathers are quite sturdy; however, when weakened by time or use, the vanes ("feathery" parts) can easily separate from either side of the solid shaft (rachis). Loose feathers or many small feather fragments on the surface of an object generally indicate active deterioration.
- *Fur, hair, and quills* are flexible keratinoid materials, but with a large range of physical appearances and characteristics. Both hair and fur can be used while still attached to the flesh of the animal, or these fibers can be removed and processed to varying degrees. Unless of very recent vintage or highly processed, hair and fur tend to be somewhat embrittled by the time they enter a museum collection. Generally, these materials should not be manipulated if the surfaces look dull, stiff, dry, or powdery, or if many broken fibers are present.
- *Porcupine quills and moose hair* are often embroidered on skin, birch bark, and fabric. Quills are specialized hollow hairs and are usually dyed, flattened, trimmed, and held to the substrate by string or yarn. Common deterioration problems are weakened or missing binding strings or yarns, quills that are loosened or lifting from the foundation, and insect damage, which can weaken or destroy the quill. Moose hair tends to break where it has been bent or knotted. These attachments should not be touched when handling these artifacts.
- *Claws, horn, turtle, and insect carapaces* are rigid keratinoid materials, while *bone, ivory, tooth, antler, and shell* are hard, inelastic materials composed of organic and inorganic substances. These items are generally among the more sturdy attachments to ethnographic artifacts and can usually be minimally manipulated without damage. Changes in surface appearance, such as BLANCHING, powdering, or cracks and crazing, indicate active deterioration. Ivory, tooth, and turtle carapaces can split or fracture, sometimes spontaneously, as a result of aging and inappropriate environmental conditions.
- *Plant parts and fibers* are organic materials formed from CELLULOSE, but they also contain other compounds that can contribute to rapid deterioration. Generally, the more processed the fiber, which occurs when it is converted into yarn, cordage, or basketry components, the more durable it will be. Plant attachments that are minimally processed, such as leaf skirts of body costumes, soon become brittle and easily break when touched. When moving such objects, the armature to which the plant material may be attached is usually the most stable component and it, rather than the attachments, should be handled. However, it is often not possible to determine where a fiber object should be grasped or supported without first moving brittle attachments. In these cases, a conservator should be consulted.

DISPLAY

Sealed cases are the best PRESERVATION environment for the display of artifacts because they help to maintain designated environmental levels and guard against dust and AIRBORNE pollutants. All cases should be constructed of materials that do not emit harmful gases, thus COMPOSITE WOODS and WOOD products should be avoided. When it is necessary to use wood products, as may be required for temporary exhibitions, a VAPOR BARRIER such as MARVELSEAL® should cover all the interior surfaces. When it is not possible to provide a true vapor barrier, then two to three coats of a calcium-containing paint should be applied to all interior wood. Recently, PLASTICS such as HDPE and urethane tooling boards such as Obomodulan® have been employed in case construction because of their INERT properties. All fabrics and materials used in cases and in contact with works of art should be ODDY-TESTED prior to installation to ensure the absence of reactive compounds.

When an ethnographic textile or fiber artifact must be displayed in an open gallery, it should be placed on a platform that is at least 12 inches in height from the floor and will allow at least 36 inches distance from its perimeter to the object. If this is not possible, then guardrails, stanchions, and motion detectors should be installed to discourage visitors from touching the objects.

To protect works of art from internally generated soil and dust, all exhibition construction work should be completed and the galleries cleaned before art installation commences, and work surfaces should be kept clean during installation.

STORAGE AND TRANSPORT WITHIN THE MUSEUM

The majority of flat ethnographic fabrics are stored and transported rolled on ARCHIVAL tubes of suitable diameter and strength, or by arranging them on a support made of archival paperboard or rigid FOAM materials. Three-dimensional and composite fiber artifacts are similarly housed on such boards or in containers, many of which are custom-made. These supports may have added internal shapes and covers, also constructed from archival materials to adequately hold and secure the artifact and to protect it from dust and light. The pieced and shaped construction of many fiber objects often requires storage solutions that give priority to the weaker elements. For transport within the museum, composite fabric-fiber artifacts should remain on or in these housings unless otherwise advised by a conservator. Many rolled textiles can be relieved from supporting their own weight by the addition of ETHAFOAM® brackets at the ends of the tubes.

When transporting a large rolled fabric in good condition within the museum, a paper or fabric sling—a flexible support placed under and around the textile—is sometimes more appropriate than its permanent storage support or tube. The flexibility of a sling may aid in moving a large textile through tight turns and narrow spaces as it maintains consistent and even support. The transfer of a rolled textile from a tube to a sling should be made by a conservator or trained technician. Slings that are stored with works of art must be made from archival-quality materials.

Occasionally, oversized three-dimensional and composite objects may require removal from their storage containers before transport within the museum. All objects should travel on sturdy carts or side trucks equipped with pneumatic wheels or other CUSHIONING and shock-adsorbing devices. For the safety of the object, it is important

that all persons participating in the move agree in advance on the most effective method. Doorway openings and hallway widths and heights should be checked before moving oversized or unusually shaped objects. Unstable composite objects and those with a high center of gravity should be braced with shaped Ethafoam® supports or WEDGES. Large or unstable objects may also need to be secured to the cart with wide cotton STRAPPING; and low-density Ethafoam® or archival POLYESTER batting may need to be placed between the object and the securing straps so that the pressure points are spread over a larger area. Objects traveling through the museum are generally covered, but the weight of the covering must not cause harm. As a general principle, no fabric or composite fiber object should be moved long distances without an underlying support of appropriate design and material.

Suggested Reading

Lloyd, Helen, Katy Lithgow, Peter Brimblecombe, Young Hun Yoon, Kate Frame, and Barry Knight. “The Effects of Visitor Activity on Dust in Historic Collections.” *The Conservator* 26, no. 1 (2002), pp. 72–84.
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6. ETHNOGRAPHIC OBJECTS WITH A SOLID CORE

Ellen Howe and Christine Giuntini

In addition to ethnographic objects made principally of textile or fiber (see Chapter 5), there are also ethnographic works of art made with a solid core or armature. As these works do not fall into a single category, the following section presents an overview of objects made with a core material to which complex layers or additional components have been applied. Core materials can be animal-, plant-, or mineral-derived substances; they can be a single solid material or a composite of pieces of the same or of different materials. Component elements are wide ranging and include, but are not limited to, pigments and minerals, oils and fats, natural resins, bodily fluids, foodstuffs, mirrors, sheets and pieces of metal, clays, soil, glass, plastic and other man-made materials, and a great variety of plant and animal materials, as noted in the previous section.

In general, these core materials and their attachments are not highly processed and were not necessarily meant to be permanent or long lasting. Among the more commonly encountered ORGANIC core materials are wood, bark, and gourd. Animal horn and turtle shells, along with bone and ivory, are also found. INORGANIC materials, such as ceramic, stone, and metal, are also known. All of these can be found as core, and also as applied materials. In most instances, the inorganic materials will form the most stable aspect of a composite object, and the chapters devoted to the caretaking of these specific materials should be consulted. However, there are very few environmental and handling guidelines that can be rigidly followed. What is essential is a basic understanding of the physical and chemical properties of the individual materials comprising an object, and how they might have chemically and physically interacted over time.

To further add to the complexity of these works, the applied layers can be affixed to the surface by a variety of means and materials: by innate adhesive properties, by penetrating the core material (inner cavities, nail, and tack), by hooks, strings, or ties, or with an applied adhesive. The diversity and often unexpected nature of the core and its applied materials, the ephemeral and often unidentifiable nature of many of them, coupled with the fact that environmental needs are often competing and at odds with each other, makes the PRESERVATION of such objects a challenge.

A few details concerning commonly found solid-core materials should be kept in mind. In most cases, ceramics are low-fired, even if decorated with elaborate layers of slip, pigment, fibrous materials, and other layers. Metals such as gold, iron, silver, and copper and its alloys are used in many cultures. However, distinctive manufacturing and decorating techniques for these materials may result in a final product whose physical and chemical properties are different from those found in Western cultures. It is not unusual to encounter the use of recycled and industrial metals of unknown composition and origin. Furthermore, time and environment have likely degraded these materials in ways that cannot be anticipated, and the core material, usually not visible, may be unstable as a result. For ethnographic works, many of these aging properties have not yet been fully studied and characterized by scientists and conservators.

Surface materials on these works are often inherently unstable or incompatible with other attached materials. Fats and oils applied to objects—for either ritual purposes or as a preservation coating—present a particular challenge because they are often nondrying, remaining tacky over time. As a result, AIRBORNE PARTICULATES can become embedded in such surfaces. Fats prone to liquefaction at slightly elevated

temperatures—even within normal climate conditions—also pose considerable problems for object handling and exhibition. In addition, the chemical interaction of oils and fats with other materials on the object can have adverse consequences, especially with metals and skins. In the case of the former, ACIDIC components from oxidation of oils will attack copper and its alloys, causing a particularly damaging form of CORROSION. In some cases, residues of use of the objects, such as libation materials or bodily fluids, can induce insect or biological attack, threatening the structural stability of the entire object.

ENVIRONMENTAL CONSIDERATIONS

Storage, handling, and exhibition protocols must be focused on prolonging the structural stability and visual integrity of ethnographic works for as long as possible. The most important consideration is the museum environment. Some of the preservation guidelines, such as LIGHTING requirements, have been addressed in Chapter 5, and these requirements can generally be applied to composite objects with solid cores. This section will concentrate on specific environmental issues concerning composite objects with solid cores.

Temperature and relative humidity (RH)

Regardless of the recommendations for individual components of diverse media, composite objects that are stable at a temperature range of 68–72°F and a relative humidity (RH) of 50%±5% should be maintained at those levels. Fluctuations in climate conditions, however, should be kept to a minimum if organic materials are present. For unstable solid-core composite objects, the optimal environment should be adjusted to favor the material that requires the most protection, whether this be the core or the materials applied to the core. Such compromises are often the best course of action in protecting a complex work of art. As an example, wooden masks covered with skin need to be kept in a climate favoring the needs of the skin to prevent it from shrinking around the inelastic wood of the core and tearing. This may mean keeping the mask at a relatively high RH, 55%±5%, because the wood has the ability to accept a broader range of RH conditions than the skin. For other complicated interactions, such as those between metals and fats, a conservator should be consulted.

Particulate pollutants

Dirt and dust are particularly hazardous to composite objects. Many of these surfaces are either sticky or highly textured and friable, thus airborne particulates and pollutants are easily deposited onto them, becoming enmeshed in the surface and difficult—if not impossible—to remove. The housekeeping guidelines outlined in Chapter 5 should be followed, and if sticky or friable surfaces cannot be cleaned, these objects must be exhibited in closed cases.

Biological agents of deterioration

Organic materials are subject to attack by a host of biological agents, most commonly insects and mold. Because it is usually not possible to thoroughly examine encrusted or enfolded surfaces, or the interiors of solid-core composites, it is important to spot signs of biological infestation at an early stage. If powdery deposits or FLAKING material seem to be accumulating around the base or on the lateral surfaces of an object, or if there are changes in color or odor, a conservator should be consulted.

HANDLING, STORAGE, AND DISPLAY

There is no straightforward methodology for handling and moving composite ethnographic objects. Unnecessary movement should be avoided and, with few exceptions, nitrile GLOVES should be used when handling composite ethnographic objects of any type. When objects need to be moved, it is important for art handlers to assume that composite ethnographic objects are likely to be friable and weak and the surface materials easily disrupted. If the art handler is unfamiliar with an object, discussion with a conservator or curator who is knowledgeable about its structure, materials, and restoration is usually a first step in planning a successful move. If the object is unusually shaped, especially if the upper sections seem heavier or stronger than lower sections, or if the object readily becomes unbalanced, the center of gravity should be estimated. FOAM WEDGES or blocks can be used to help the object maintain its favored position. It may be necessary to touch the layers without applying pressure in order to find resilient surfaces to hold on to. For large or very unstable objects, two or more handlers may be needed. For most of these objects, a study support board upon which the object can be exhibited and stored is the ideal means of transit. The board, rather than the work of art, can be lifted and moved, thus sustaining most of the handling pressures.

In addition to friable surfaces, tacky surfaces also need protection. Objects with tacky layers should not be stored or wrapped for transport in fibrous materials such as PAPER and TISSUE, or POLYETHYLENE foams such as VOLARA®. To date, there is no ideal material for contact with such surfaces, but, if necessary, the least damaging option is to insert a piece of MYLAR® or food-grade WAX PAPER between the object and any bracing or wrapping material. Even when following the best protocols for moving ethnographic objects, applied parts or surface layers may become damaged or detached. Mindfulness is the operative word in these cases: gather up the pieces and place them in a container or a PLASTIC BAG, whichever seems most appropriate, and call the conservator.

Suggested Reading

Barclay, Robert L., et al., eds. *Symposium 86: The Care and Preservation of Ethnological Materials*. Ottawa: Canadian Conservation Institute, 1986.

Doyal, Sherry, Christine Murray, and Linda Shelley. “World Culture Collections.” In *The National Trust Manual of Housekeeping: The Care of Collections in Historic Houses Open to the Public*, pp. 545–55. Boston: Elsevier, 2006.

Hill, Lewis, and Sue Giles, eds. *“Where to Start, Where to Stop?” Papers from the British Museum/MEG Ethnographic Conservation Colloquium*. Hull: Museum Ethnographers’ Group, 1995.

7. MUSICAL INSTRUMENTS

Stewart Pollens

ENVIRONMENTAL CONSIDERATIONS

Environmental conditions for musical instruments are based on the same principles as other works of art made of ORGANIC and INORGANIC materials. These objects are extremely diverse in their components and configuration, but often present special considerations because of their acoustical and structural elements and complex mechanical components. Some protective coatings and other treatments that might be applied to prevent or retard deterioration in other art objects cannot be used on musical instruments because they may interfere with their tonal qualities and mechanical action. Musical instruments differ from most other art objects in that they must be handled when used or studied. Their unique PRESERVATION issues require a specialized conservator to assemble and disassemble them, and to remove fingerprints, condensed water vapor, rosin dust, and other materials that settle on them in the normal course of museum activity.

Temperature and relative humidity (RH)

Musical instruments made primarily of wood and organic materials should be protected from extremes and fluctuations of temperature and RELATIVE HUMIDITY (RH), whether or not they are used in performance. Optimal environmental conditions for most objects in this category are 68°±2°F and 50%±5%RH. Wood shrinks when the humidity decreases and swells when the humidity increases, but the rates of shrinking and swelling vary with grain direction. Longitudinal dimensional changes are negligible; radial and tangential changes are significantly greater. Because instruments such as violins, lutes, guitars, harpsichords, and pianos have soundboards and case structures that are reinforced by ribs and buttresses that are often glued across the grain, changes in humidity may cause soundboards and cases to crack or warp, and repeated fluctuations may cause the glue joints between these parts to fail. Changing humidity will also cause gut strings to expand and contract and thus go out of tune. Temperature change will have a similar effect upon metal strings, and because brass and steel strings expand and contract at different rates, they will not rise and fall in pitch together, thereby compounding tuning problems. It is important to be aware of objects that have specific requirements.

Sustained humidity levels above 65% encourage the growth of mold and mildew, which are especially destructive to key and action cloths, felts, leather, and mechanical parts. Metal instruments should also be kept at reduced RH. At 65%RH or higher, BRONZE DISEASE, which can be initiated by SALT deposits from perspiration, may erupt in brass, and iron parts may rust. Ethnographic instruments from tropical environments that have not been in the collection sufficiently long to have acclimatized may be more safely stored and exhibited at higher humidity levels, but generally not above 65%.

For musical instruments that are played, performance areas should be maintained at the same temperature and RH levels as galleries and storage rooms. Strong stage lights must be avoided because they generate damaging heat.

Light

Fig. 1 Fading of violin varnish that was exposed to 5 foot-candles illuminance for one year. The light source was a single 60-watt, 2800˚K quartz-HALOGEN lamp directed from a ceiling fixture through a 1/4-inch-thick PLEXIGLAS® vitrine. Note the distinct "shadows" of bridge, tailpiece, fingerboard, and strings.

Illumination levels should be kept as low as possible for instruments composed of organic materials. Wood instruments, including those with cabinetry made of walnut, mahogany, and rosewood, are readily bleached by sustained exposure to LIGHT, and varnishes tinted with fugitive organic dyes will fade **(Fig. 1)**. Ivory will yellow if stored in total darkness, but even moderate levels of artificial illumination will keep it white. To prevent masked areas from yellowing, ivory woodwinds should be exhibited so that light reaches all surfaces, and pianos and other keyboard instruments should be stored with their fallboards in a raised position to receive some ambient light. Ethnographic instruments made of fragile organic materials, such as feathers, textile fibers, or lacquer, should not be exposed to illumination greater than 5 FOOT-CANDLES. For composite instruments made of organic and inorganic materials, the light level and amount of exposure should be based on the most vulnerable component.

Biodeterioration

Instruments and storage cases should be regularly examined for woodworm, mites, silverfish, and other pests. INTEGRATED PEST MANAGEMENT procedures should be followed if infestation is detected. Chemical FUMIGATION, desiccation, and FREEZING are not appropriate methods of eradicating these pests from musical instruments. A treatment of high heat (such as the nonchemical Thermo Lignum® process) should not be employed in the disinfestation of carrying cases made of wood, as this causes wood to release highly CORROSIVE agents that will aggressively attack metal instruments stored in or around them. ANOXIC TREATMENT is recommended, providing that the INERT gas used to kill the pests is humidified.

HANDLING

Musical instruments must be handled in the same manner as other works of art in a museum collection; however, unlike most objects, many are used in performance and thus have particular requirements. Those that have been previously restored to playing condition require continual maintenance; for example, harpsichords and pianos need to be regularly tuned and periodically examined for signs of deterioration, such as ungluing of joints and seams. Any adjustment to an instrument's voicing, regulation, temperament, or pitch must be done by or in collaboration with a specialist conservator.

Whether or not musical instruments in a museum collection should be played is a philosophical issue often debated by curators and conservators. A great many museums have declared a moratorium on restoring and playing their instruments, while others have not. Whatever the decision, the same preservation safeguards must be followed.

Before handling, moving, or preparing for playing, instruments should be carefully examined, noting existing damages and points of weakness. Protective GLOVES should be worn when handling most instruments, the type of glove determined by the material from which the object is made and its condition. The strings of a keyboard instrument must never be touched with bare hands—skin oils and perspiration are highly corrosive and will etch these materials, so avoiding contact with varnished, painted, and gilded surfaces is imperative. Metal instruments or metal components, even if lacquered, should never be handled with bare hands. In these instances, NITRILE or clean cotton gloves are appropriate. LATEX gloves must not be used because they are processed with sulfur and are thus potentially corrosive. Cotton examination gloves tend to be slippery, so they should not be used in lifting heavy instruments such as pianos and harps.

Trays lined with COTTON BATTING or POLYETHYLENE foam should be used for examining and carrying small instruments or parts, such as disassembled woodwind joints. To support and prevent them from rolling, WEDGES of dense polyethylene FOAM can be used. Work surfaces must be clean and free of debris; and dangling jewelry, keys, and ID cards must be removed or secured before examining, tuning, or moving an instrument to prevent inadvertent scratches or other damage. More than one person may be required for moving large instruments. In all procedures, the course of action should be established in advance.

Handling requirements by type of instrument

Each type of instrument has special handling requirements because of its particular acoustical and structural elements and mechanical components. Only a conservator or trained individual should assemble or disassemble instruments.

- *Keyboard instruments*. Movement of keyboard instruments, especially early wood-framed ones, should be kept to a minimum, and never repositioned after they have been given their final tuning prior to a performance. Lifting or rolling these objects even short distances or on uneven flooring will disturb their tuning. After playing or handling, fingerprints and perspiration should be removed from keyboards with a soft cloth.

Fig. 2 Stringed instruments such as violins, viols, lutes, and guitars are safely carried by the neck, with the other hand supporting the bottom of the instrument.

- *Stringed instruments*. Instruments such as violins, viols, lutes, and guitars are safely carried by the neck in one hand, with the other hand supporting the bottom of the instrument **(Fig. 2)**. It is not necessary to use protective gloves when carrying most

stringed instruments; however, after handling, fingerprints should be removed with a soft cloth. When violins and violas are played, a conservator should assess whether a chin or shoulder rest may be safely attached. Performers must not wear cosmetics, hand lotions, or perfumes in areas that will be in contact with the wood. After playing, rosin dust should be gently brushed or wiped off the varnished surfaces and from the strings and fingerboards with a soft brush or cloth. Commercial cleaners or polishes to remove rosin should not be used. Old, caked-on rosin should only be treated by a specialist conservator. Bows are safely held by the frog, leather grip, or wrapping, and best carried in an upright position. The bow hair should not be touched, as skin oil will prevent it from drawing sound from the strings. Bow hair should be loosened after playing by giving the button a few twists or unclipping the frog. If left under playing tension, the bow may warp or lose its camber.

- *Woodwind or brass instruments*. Before hand-carrying a woodwind or brass instrument, the assembly and security of the separate components (joints, tuning slides, bits, and crooks) must be determined to prevent them from loosening. Mouthpieces and clarinet or oboe bells, for example, are relatively heavy and can fall off if not properly fitted. Wind instruments employ special oils and greases for lubricating tenons, valves, tuning slides, and crooks. With time, they evaporate or harden, causing parts to seize. Only trained personnel should handle these instruments if parts cannot be disassembled with a light, twisting motion, or if cleaning is required for instruments that have been played or handled without gloves. Brass instruments and the keys of woodwinds are readily damaged by extraneous objects placed in their fitted cases; thus care must be taken to avoid such hazards.

STORAGE

All materials used for storage, mounts, VITRINES, carrying cases, or wrapping for transport should be ODDY-TESTED. WOOD and COMPRESSED WOODS, ACIDIC cardboard, many SYNTHETIC fabrics, paints, and ADHESIVES exude VOLATILE ORGANIC COMPOUNDS (VOCs) that will TARNISH instruments made of brass and silver and degrade instruments comprising organic components. Because of this, manufacturer-supplied carrying cases are generally not safe for long-term storage and should be kept in a separate vented room. RUBBER-based materials emit sulfur, which tarnishes metals, and are particularly damaging to silver, thus elastic bands and latex gloves must not be in proximity to brass and silver instruments whether for binding parts together or attaching labels, and should not be left in carrying cases or storage units. Similarly, foam rubber and other rubber-based products should never be used for storage, PADDING, lining, or packing for transport.

Instruments should be displayed and stored in cases made of inert materials, such as GLASS, ACRYLIC SHEETING, and POWDER-COATED METAL. Wind instruments made of metal or having metal keywork and fittings should not be stored in their commercially made carrying cases.

Materials for wrapping, support, lining, and padding cabinets and drawers must also be inert. These may include polyethylene foam sheeting and blocks, polyethylene bags, UNBUFFERED, ACID-FREE paper, and ARCHIVAL board. Mounts and armatures should be hard-soldered brass or welded steel, acrylic sheeting, and other stable PLASTICS. Display stands and mounts should be designed to facilitate easy removal of instruments that are frequently played or examined, and to support detachable parts such as clarinet bells, mouthpieces, slides, and tuning crooks. Acrylic, POLYESTER felt, or VOLARA® are recommended for padding between the mount and the instrument.

Polyolefin heat-shrink tubing can also be used as a protective BARRIER on metal mounts, but vinyl plasticized tubing, and wool felt or cloth, should not be used for this purpose.

Instruments should be covered with polyethylene plastic sheeting or bags while in storage to protect from dust and particulate matter. These materials should not be sealed, in order to avoid condensation in the event of a failure in the climate-control equipment (HVAC). Silver instruments can be wrapped in cloth bags IMPREGNATED with colloidal silver, such as PACIFIC SILVERCLOTH®, or in polyethylene bags impregnated with copper. Cloth bags or trays filled with ACTIVATED CHARCOAL, which absorbs AIRBORNE sulfur compounds and other corrosive gases, can also be placed in drawers and cabinets. These specially treated materials must be monitored and replaced periodically. To prevent rusting of iron and steel strings and springs, ACID-FREE PAPER cut to shape and treated with a vapor phase inhibitor should be placed over or in the vicinity of vulnerable sites.

Storage requirements by type of instrument

Many instruments have specific storage requirements that must be overseen by a specialist conservator, as they require knowledge of their mechanism and components.

- *Keyboard instruments*. To prevent damage to the case and soundboard of keyboard instruments, springs, stop knobs, couplers, and other mechanical linkages must not be under tension, and those in long-term storage should have their strings slackened. This should be done gradually and evenly throughout the range of the instrument, but with sufficient tension to prevent string coils from loosening on tuning pins. To prevent yellowing, keyboards should be exposed to moderate light but covered with acrylic or polyethylene sheeting to protect from dust settling on them. Harpsichords with pedal-operated stop actions should have their pedals shifted into their off position to relieve tension on the springs; and organs, after playing, should have their stop knobs pushed back, and couplers or combination mechanisms that work against springs should be released or disengaged. Harp pedals should be hitched in the highest position to relieve pressure on the strings.
- *Stringed instruments* should be detuned to reduce tension on wood components and to prevent gut and silk strings from breaking due to a drop in humidity; however, this should be done gradually and evenly from string to string. There should be sufficient tension on the strings to prevent bridges and soundposts from falling. Violin bows should be stored with the hairs slackened to avoid damage to the stick if the humidity drops.
- *Woodwinds* are generally stored disassembled, the cork and thread-wrapped tenons checked and lubricated periodically before placing in storage. Those with nonremovable bells or other protuberances extending beyond the body of the instrument should not be stored in a horizontal position without supporting the body of the object.
- *Music boxes and automatic instruments* should be routinely cleaned and lubricated, and stored with their springs let down and exposed mechanical parts, such as combs, cylinders, disks, and springs, protected with a rust inhibitor, as described above.
- *Ethnographic instruments*. Special storage and exhibition methods must often be devised for ethnographic instruments made of vulnerable materials to protect them from airborne dust, as many of their component materials are virtually impossible to

clean. Storage cabinets with doors fitted with gaskets and unsealed polyethylene bags are recommended. Instruments with hygroscopic or compromised materials may require MICROCLIMATES for storage and display.

TRANSPORT

Standard museum practices of acclimating an object for 24 hours upon arrival must always be followed. For local trips, instruments should be transported in climate-controlled vehicles and not exposed to elevated temperatures or sunlight. Heavy objects should never be placed on top of an instrument case. Recommended materials, noted above, should be used for packing. In addition, specific guidelines must be followed for the different types of instruments.

Keyboard instruments

When moving a keyboard instrument, a spotter should be on hand to oversee the operation, checking for door thresholds and other obstacles. The lid should be closed before lifting or rolling the instrument across the floor, and the legs checked to determine that they are in good condition, properly tightened or toggled in place, and casters firmly attached and able to roll freely. Pianos should never be shoved to clear a threshold, but lifted while rolling to take some weight off the legs. Most harpsichords have separate stands that are not attached to the instrument. When the instrument is lifted off the stand and moved, an art handler should be ready to reposition the stand beneath the instrument.

Before packing a piano or harpsichord for transport, the casework should be carefully checked for loose veneer and moldings. If these or other parts are detached, a specialist conservator should be consulted: improper treatment can result in severe damage or loss of material. Painted or lacquered lids and cases should be treated like panel paintings and may require special handling or crating. Unhinged prop sticks, candle holders, music desks, benches, tuning wrenches, and other parts should be labeled, inventoried, and packed separately. Threaded legs are removed by twisting; toggles, which are used with legs fitted with cast-iron plates, must be rotated away from the legs just before they are removed. When removing pedal lyres, the pedal rods should be numbered or secured in place so they can be replaced in the proper sequence. Pedal trapwork must be protected if piano cases are placed on carts or dollies, or are shipped flat.

Stringed instruments

In many instances, violins and other stringed instruments can be safely transported in their fitted cases, which should employ a suspension system that isolates the instrument from shock, as well as dampits or other means of maintaining humidity, especially for air transport. For long trips and air travel, the instrument should be detuned, but leaving enough string tension to prevent the bridge and soundpost from falling down. If a fitted carrying case is not available, the packing should exert only minimal pressure on the body of the instrument. The bridge and strings of violin- and viol-family instruments must be completely isolated from the case or packing material, as an impulse delivered to the bridge or strings may cause great damage. For transport, it is advisable to place a folded

cloth under the tailpieces of violins, violas, and cellos to prevent damage to the soundboard should the bridge fall in transit. If the neck is unstable, a specialist conservator should fashion a thick strip of acid-free matboard that can be gently wedged between the fingerboard and the top of the instrument, as this will protect the instrument should the neck come loose in transit.

Woodwind and brass instruments

Most woodwind and brass instruments can be safely transported in their fitted carrying cases. If such cases are not available, these instruments should be disassembled by a specialist conservator and the individual joints and other loose parts, such as crooks and brass mouthpieces, inventoried and packed separately. Instruments should be supported by shaped blocks of polyethylene foam.

Percussion instruments

For percussion instruments, it is advisable to loosen the heads of drums that are to be moved to a different climate. Extra padding or a fitted, protective board for drumheads should be provided, as these components are delicate and easily perforated. Marimbas and xylophones have bars that are generally strung together to maintain their order and attachment to their stands. If the bars are loose, a system should be devised to attach them to the stand; or they may be individually wrapped, numbered sequentially, and packed separately. Beaters should be labeled and inventoried to prevent them from getting lost or switched with other instruments.

Ethnographic instruments

Ethnographic instruments are often made of extremely fragile materials, such as gourds, palm leaves, reed and plant fibers, and minimally cured animal skins and feathers. They may present difficulties in packing, and thus the advice of a conservator of ethnographic materials should be sought (see Chapters 5 and 6).

Suggested Reading

Barclay, Robert L., ed. *The Care of Historical Musical Instruments*. Ottawa: Canadian Conservation Institute, 1997.

Berner, Alfred, J. H. van der Meer, and Geneviève Thibault. *Preservation & Restoration of Musical Instruments: Provisional Recommendations*. London: International Council of Museums, 1967.

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8. WOOD: FURNITURE AND DECORATIVE WORKS OF ART

Mecka Baumeister

Most historic pieces of furniture and many decorative works of art have complex structures and incorporate diverse materials. In construction and decoration, these objects regularly combine different woods and wood veneers, and may include steel, brass, pewter, silver, tin, chrome, various stones, glass, mother-of pearl, bone, ivory, horn, tortoiseshell, antler, parchment, papier-mâché, straw, leather, shagreen, textiles, and upholstery materials. The surfaces may be decorated with metal leaf or paint, lacquer, japanning, or coated with a transparent finish. A wide range of plastics and modern synthetics are encountered on furniture and objects manufactured since the beginning of the twentieth century. In order to establish proper procedures for handling and appropriate environmental conditions for display, storage, and transport, it is important to understand an object's basic construction, its secondary and decorative materials, its condition, and the factors that contribute to its deterioration.

ENVIRONMENTAL CONSIDERATIONS

As a preventative measure, it is important to provide an appropriate environment for historic furniture and decorative arts collections. This can be very complicated because the diverse components that make up a single object may require very different environmental conditions.

Organic materials

Furniture and objects made of ORGANIC materials such as wood, bone, ivory, horn, tortoiseshell, paper, parchment, leather, shagreen, textiles, and plastics are subject to damage and deterioration from exposure to LIGHT, from fluctuations in temperature and RELATIVE HUMIDITY (RH), and from pollution and biological attack. Relative humidity and temperature have a major effect on these materials, as most are hygroscopic and will absorb moisture in their attempt to maintain equilibrium with the relative humidity of their environment. When the climate changes, dimensional expansion and contraction, cracking, warping, twisting, lifting, FLAKING, and failure of structural joints and adhesives can occur. For furniture and decorative art made of diverse materials, such as those veneered or decorated with metal leaf over a gesso ground, each component can react differently to changes in relative humidity, expanding and contracting at dissimilar rates and in opposing directions. Furthermore, FUNGAL and INSECT INFESTATIONS are promoted in warm, humid environments (see Chapter 20 for a discussion of biodeterioration). The organic materials that make up most furniture require a constant RH of about 50% with a fluctuation of ±5%, and a temperature of 68–72°F. The actual temperature and RH are less critical than maintaining an environment free of sudden or extreme fluctuations. Furniture and objects maintained in a stable environment over a long period of time will reach equilibrium with their surroundings. If it is necessary to move an object to another location, it should be gradually acclimatized to the new environment prior to reinstallation.

Inorganic materials

INORGANIC materials found on furniture and decorative works of art, such as metal, stone, and glass, are also sensitive to their environment, although exposure to light generally poses a less significant threat. Metals, used for structural elements, fasteners, hardware, decorative mounts, inlay in marquetry, or in the form of leaf, are susceptible to CORROSION by exposure to RH levels above 45%. Higher levels can also accelerate TARNISHING, a condition resulting from contact with air pollutants and gases emitted by materials used in gallery and VITRINE construction and by various organic materials used in the fabrication of the artwork itself (such as certain WOODS, adhesives, or plastics). For furniture and objects composed of organic materials and metal, an environment of 47%±3%RH and 68°±3°F is a reasonable compromise.

Synthetic materials

Special storage and display conditions are necessary for furniture and objects made of SYNTHETIC materials. While some PLASTICS are relatively stable, others are inherently unstable and their inevitable deterioration is irreversible. Their lifetimes can only be extended by maintaining them under conditions specifically required for the type of material. For such highly unstable materials, decomposition can occur even in environments of minimal relative humidity. This is particularly true for the chemical degradation of CELLULOSE NITRATE and CELLULOSE ACETATE, which evolve reactive ACIDS even more rapidly at higher RH levels. The degradation of RUBBER and some plastics is accelerated by their interaction with atmospheric oxygen. These include polyurethane and LATEX FOAMS, which will disintegrate, turning into sticky or powdery masses. Physical deterioration of plastic can also be caused by the loss of plasticizers, which can migrate to the surface, leaving the plastic embrittled and causing shrinkage. When this occurs, the surface of the plastic may become sticky. For all plastics, the potential loss of plasticizer, as well as the rate of chemical degradation, increases with higher temperature.

To provide the best possible care for objects made of or incorporating plastics, it is important to correctly identify the material. In the absence of specific information, plastics should be viewed as inherently unstable, stored in a dark, dust-free environment with good air circulation at low temperature, approximately 40–50ºF (5–10ºC) and RH below 45%, and monitored at frequent intervals. Very low RH or ANOXIC (oxygen-free) environments may be necessary for the storage and display of some plastics and rubber.

Light

The organic components of furniture and decorative works of art are readily and irreversibly affected by light. Light radiation degrades these objects in several ways: it can break down surface finishes; cause discoloration and deterioration of stained, painted, and lacquered surfaces, textiles, and plastics; and cause light-colored woods to yellow or darken and dark woods to fade. These visual changes are particularly detrimental to objects with inlays and marquetry, where contrasting colors and tonalities constitute an important aspect of the design. Light can also be a localized source of heat, causing embrittlement, deformation, and cracking of many organic materials. It is important to understand that an object’s cumulative exposure to light is significant:

prolonged exposure to low light levels can cause the same damage as brief exposure at far higher levels. For most furniture and related objects, lighting should not exceed 15–20 FOOT-CANDLES; a maximum of 5 foot-candles is recommended for objects incorporating materials that are particularly light-sensitive, such as textiles, stained woods, and Asian lacquer. Because shorter wavelengths are the most damaging part of the spectrum, ULTRAVIOLET (UV) light, which is a component of DAYLIGHT and some artificial lighting sources, should be filtered out. Direct sunlight should never fall on furniture and objects made of organic materials. For display, light-sensitive and well-preserved pieces should be rotated frequently, and not exhibited on a permanent basis.

HANDLING

One of the first steps in protecting the surface of decorative art objects that will be handled is to avoid wearing jewelry, belt buckles, keys, or other sharp, hard items that might scratch or otherwise damage these works of art. Thin, slip-resistant, powder-free nitrile GLOVES should always be worn when handling metal and plastic objects; objects with unfinished wood; metal-leafed, painted, or lacquered surfaces; and light-weight pieces. Gilded and painted surfaces on gesso grounds are especially susceptible to cracking when put under pressure, thus handling should be done in areas without decoration. Gloves should not be used when handling heavy works in this category because a good grip is required; in these cases, the hands should be washed and dried prior to contact with the object at its structurally strongest elements.

Examination

It is important to ensure that the object is sound before it is handled or moved. To assess stability, the condition of structural elements, joinery, hardware, surface decoration, damages, and repairs need to be closely examined under good ambient light and, if necessary, using a flashlight for the interior, underside, and back. A specialized conservator should be consulted if the object's state of preservation is not certain.

Being alert to signs of BIODETERIORATION is critical. The presence of insect exit holes on surfaces is not necessarily an indication of active infestation, but pests may be active when the holes have sharp, slightly raised, light-colored edges and the wood inside appears light-colored, or when fresh FRASS is present. In such cases, a biodeterioration expert should be consulted immediately, and the object isolated to prevent infestation of other pieces. Surfaces should also be checked for mold and fungi. If these conditions are observed, other susceptible objects in the same gallery or storage area should also be carefully inspected (see Chapter 20 for a discussion of pest management).

Lifting

Furniture and decorative works of art should always be lifted, even if fitted with castors, as pushing, sliding, or dragging along the floor puts tremendous strain on the construction and could cause a leg or foot to snap off. These objects should never be picked up by their projecting moldings or carving, and chests, cabinets, or caskets should not be lifted by their handles. A chair should never be lifted by its arms or back rest, which are generally not strong enough to carry its weight.

For safe handling, furniture and objects should be lifted by the structurally strongest horizontal elements or their load-bearing members. For example, a table should be lifted by its apron where it is joined to the legs, and not by its top, as the attachment of the top to the base may be strained. A small chair can be handled by holding the front and rear seat rails, keeping the chair back vertical and sideways so as not to obscure the pathway. It is generally safer to carry furniture with two or more people. Heavy and large pieces should be lifted by four people, each with one hand supporting the object from below and the other hand on its side to prevent tilting.

Display and storage

To maintain structural stability, all legs and supports of a piece of furniture or object must share the weight equally. Each object must stand level, which might require the use of WEDGES made of wood or an INERT synthetic material. For furniture that needs to be opened, handles, pulls, knobs, catches, bolts, locks, and hinges must be in good condition and functional. If they are, doors, fall-fronts, or drawers may be opened and closed carefully by applying equal pressure without force. Open display of these elements may require special mounts to avoid straining hinges or other hardware and to support their weight. Freestanding furniture and objects should be placed on platforms for protection from touching, accidental impact, or crowded galleries. Care must also be taken when objects are displayed on top of furniture that they rest on pads made of felt or closed-cell foam such as VOLARA® to protect the surface of the furniture.

HOUSEKEEPING

Regular, overall cleaning of furniture and decorative works of art is essential to remove or reduce the buildup of dust, soiling, air pollutants, and debris. Dust and other surface deposits are hygroscopic and thus attract and hold water vapor, which can be dangerously alkaline or acidic.

Furniture and objects should be cleaned from top to bottom with electrostatically charged dust cloths, clean cotton rags, or soft, long-haired brushes (hake or sable). Dust can be very abrasive, thus surfaces should be wiped gently and the dust cloths refolded or rotated frequently. If a large accumulation of particulates is present, one can use a soft brush and simultaneously collect the deposit with a HEPA-filtered VACUUM CLEANER. The attachment of the vacuum cleaner should always be held slightly above the surface without touching the object. Great care must be taken not to snag lifting veneer or inlay, loose carving, or flaking surface decoration. A vacuum cleaner with variable suction control should be used for particularly fragile surfaces. The suction should be adjusted so that particles are lifted from the substrate without disturbing delaminating surface layers. As an additional precaution, a fine-mesh POLYESTER screen can be fixed over the nozzle so that bits of surface decoration, veneer, or carving that become separated during cleaning are not lost. Dislodged pieces should be placed in a lockable PLASTIC BAG or small container labeled with the date, accession number, and precise location from which they originated so that they may be reattached by a conservator. If the surface of an object is in such poor condition that it requires stabilization prior to cleaning, a self-supporting DUST COVER should be made as an interim measure.

Plastics and rubber should be handled as little as possible and with special care, as they may be more brittle than they appear. Routine cleaning should be restricted to removing dust with a soft hair brush and a HEPA vacuum cleaner from nonsticky

surfaces. Rubbery or sticky plastics should be placed on MYLAR® sheets to isolate them from shelving or platforms.

STORAGE

Furniture and many decorative art objects are susceptible to water and heat damage, thus should never be placed in proximity to plumbing, water and steam pipes, radiators, and HVAC ductwork. Duct outlets allow blasts of hot or cool air to enter the room, while return ducts can draw dust-laden air across the works of art. Light also poses a serious hazard. The organic constituents of furniture deteriorate upon exposure to light. Illumination should be provided only when objects are on display; while in storage, furniture and related objects should be kept in darkness, and for study and treatment, light levels should be no higher than required for the task. FLUORESCENT LIGHTING in storage areas must be covered with UV filtering sleeves.

Synthetic and some natural organic materials, including various wood species used in the manufacture of furniture and decorative works of art, release acidic vapors (VOLATILE ORGANIC COMPOUNDS) that can react with various metals. Materials and artifacts that are likely to produce corrosive gases should be separated from objects that could be adversely affected. Specific chemical absorbers (SCAVENGERS) can be included in storage containers and display cases with artifacts that pose this risk. Other strategies to mitigate the impact of volatile agents include maintaining RH levels below 45% and ensuring good air ventilation.

Covers, compact storage, or other types of closed compartments will help to protect furniture and objects from light and will also keep dust accumulation to a minimum. Custom-made dust covers, or loose-fitting, light-weight, low-friction fabric (cotton, rayon, or TYVEK®) will allow air movement, thus preventing trapping of moisture and noxious gases. Labels on such covers should include an image of the object to minimize handling. These covers should be regularly washed as part of the storeroom cleaning program and properly stored while pieces are on display. As a temporary alternative, thin Mylar® sheets, placed loosely over the object may be used for dust protection on surfaces that can withstand the STATIC CHARGE of Mylar®. For metal-leafed, painted, lacquered, or plastic furniture or objects with lifting, flaking, or sticky surfaces, a framework should be used to prevent covers from touching surfaces.

In storage, furniture and decorative works of art should be easily accessible for the protection of both the objects and the art-handling staff. Furniture and objects should never be stacked. Light-weight pieces should be placed in single rows on shelving made of inert materials such as POWDER-COATED enameled steel; heavier pieces should be housed on lower shelves or placed off the ground on individual movable platforms with locking wheels. Any items removed from an object should be kept in inert storage containers and labeled with accession number and location of the object. The object itself also should have a reference to components stored elsewhere. Oversized items, such as mirrors and architectural elements, may require racks or customized shelving.

TRANSPORT

Case furniture and cupboards that consist of several sections should be dismantled and transported separately. Stone, scagliola, or glass tops must be removed and always handled and transported in a vertical position (as described for ceramics and glass in Chapter 2). Folding screens may be transported either dismantled, in individual panels,

or folded together with an INTERLEAVING material protecting opposed surfaces. Doors and drawers should be locked or secured with wide cotton twill TAPE so that they do not open unexpectedly. Shelves and other adjustable elements should be removed prior to transport if they are not securely attached, and their position noted. Where doors, fall-fronts, drawer fronts, and lids are in contact with decorated surfaces, they should either be transported separately or covered with ACID-FREE tissue paper to avoid abrasion from vibration during transport. Moving handles or pulls should be wrapped in situ with TISSUE paper.

For transport, furniture and decorative works of art, when possible, should stand in their intended position in which they support their own weight. If this is not possible, these objects or frames should not travel while resting on carved decoration or other protruding elements; blocks, wedges, and PADDING should be used to raise the decorated surface so that the weight of the piece is supported by structural elements that are relatively flat. Ideally, the flatbed or side cart should be larger than the object it transports so that no elements project beyond the perimeter of the vehicle. The object must be securely positioned on the cart or strapped to it. Points of contact, where the object is leaning against a side truck or held by straps, need to be protected with clean, nonabrasive padding such as Volara®, and placed at the structurally strongest parts of the furniture, covering as little of its surface as possible. Before disposing of padding materials, one must carefully check for small dislodged fragments.

The cart or truck should have pneumatic or rubber wheels that will absorb shock and vibration during transportation. The vehicle should be moved slowly. Care must be taken to avoid jolting objects when traversing thresholds, elevator entrances, or other uneven surfaces. Transporting furniture and decorative works of art in public areas of the museum should be avoided.

Suggested Reading

Lloyd, Helen, Peter Brimblecombe, and Kathy Lithgow. “Economics of Dust.” *Studies in Conservation* 52, no. 2 (2007), pp. 135–46.

National Committee to Save America’s Cultural Collections. *Caring for Your Collections*. New York: Abrams, 1992.

The National Trust Manual of Housekeeping: The Care of Collections in Historic Houses Open to the Public. Boston: Elsevier, 2006.

Rivers, Shayne, and Nick Umney, eds. *Conservation of Furniture*. Oxford: Butterworth-Heinemann, 2003.

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9. ASIAN LACQUER

Donna Strahan

Asian lacquer, also known by its Japanese name *urushi*, is produced from the sap of various trees found throughout Asia. The trees are tapped by cutting slashes through the bark, collecting the exuded sap, and then refining it. *Urushi* is a liquid emulsion that, when spread as a film, sets by polymerization to a tough, flexible, and durable layer. It is used as a coating and an adhesive, properties resulting from its unusual and complicated chemical structure.

Urushi has been used since ancient times and continues to be made today to create a wide variety of objects. It was first used during the Neolithic period in China, as early as 4000 BCE, as a coating on baskets to preserve and harden the substrate. Other early objects to which it was applied include lifesize sculpture, furniture, armor, and objects of everyday use such as boxes, bowls, and chopsticks.

There are many different lacquer techniques, each relying on multiple layers of *urushi* with or without additives. Among the techniques are painting with lacquer, inlaid lacquer, carved lacquer, surface relief work, and lacquer combined with metallic leaf and powders (*makie*). Often several techniques will be combined in an object. The varied substrates may include wood (pine, paulownia, willow, elm, camphor), basketry, metal (gold, silver, bronze, iron, lead, pewter), cloth (linen, hemp, silk), leather (horse, elephant, camel, rhino), ceramic (porcelain), shells, ivory, tortoiseshell, mud mixed with straw, and paper. The various types of condition problems encountered in these works of art, affecting the lacquer layer, the substrate, or their interaction, are the result of adverse environmental conditions and mishandling.

ENVIRONMENTAL CONSIDERATIONS

Lacquer objects cannot be subject to extremes and fluctuations of temperature and RELATIVE HUMIDITY (RH). When environmental conditions are not controlled, lacquer, like other ORGANIC materials, can suffer serious physical damage. Very moist environments will cause the ground layers and base materials to expand and crack the lacquer above them. Very dry conditions will desiccate the ground layers and base materials, also leading to cracking and FLAKING of the lacquer. The most important consideration in the PRESERVATION of Asian and Western lacquer is to maintain constant temperature and RH levels. Lacquers should be kept at 50–55%RH. Objects on loan from Asia should be kept at 55–60%RH. If there is certainty that a loan object from another collection has been kept at 60%RH, it is crucial to maintain this level. The most suitable temperature range is 68–72ºF.

As an organic resin, lacquer is readily subject to degradation from LIGHT. Light-induced degradation depends as much on the specific species of tree from which the lacquer sap originates, its processing, and the decoration technique, as on the history and current state of the object. Illumination levels for exhibition should not exceed 5 FOOT-CANDLES (50 lux) for six months once every five years, or five weeks per year. Exposure to ULTRAVIOLET (UV) radiation and temperature extremes will provoke deterioration, breaking down chemical bonds and causing irreversible discoloration. As a result of these chemical changes, lacquer becomes pale, matte, or bleached out in appearance.

HANDLING

Careful examination is necessary to provide a true picture of the object, its history, and its condition problems. Because of the delicate surface of lacquer, powderless nitrile GLOVES should be worn at all times when handling these objects. Fingerprints are the most common damage to lacquer objects. The ACIDS and alkalis in skin oils etch into the surface over time and cannot be obliterated other than by removing part of the original lacquer surface, a practice unacceptable for a work of art. Lacquer that has been improperly dried can on rare occasions provoke dermatitis, but this will be precluded if gloves are worn.

Flaking is also commonly encountered in lacquer; thus to avoid snagging and dislodging any insecurely held areas or decorative elements, cotton gloves should not be worn. Pronounced flaking and detached pieces, which should be saved in small containers, must be brought to the attention of an objects conservator.

Fig. 1 When lifting, one hand should support the bottom of the object, the other the side, being careful not to grip with great pressure, as this could provoke cracking of insecure layers.

Because of the original functional nature of many of these works of art, lacquer objects may have had undergone several campaigns of repair, at times inappropriate or resulting in significant alteration of the original object. Lacquer objects with covers or component parts should be carefully studied before handling and disassembling. One should not attempt to fit sections together if they have become distorted as a result of restoration or the ravages of time, as this can result in abrasion and flaking. When handling lacquer objects, one should avoid touching any decorative inlays and metal

foils, as they may be lifting or insecure. When lifting, one hand should support the bottom of the object, the other the side, being careful not to grip with great pressure, as this could provoke cracking of insecure layers **(Fig. 1)**.

In addition to surface damage, when examining and handling a lacquer object, it is important to note problems related to its substrate, including crumbling and cracking. For substrates made of WOOD, these cracks, provoked by expansion and contraction, mirror both the grain of the wood and can run perpendicular to it. Some lacquer objects may appear to be in excellent and robust condition; however, their unexpected light weight is often the first sign that the wood, or other CELLULOSIC substrate, has been attacked by insects. Because lacquer is poisonous to insects, often only a powdery core remains beneath the intact shell, making these objects extremely fragile. When possible, the compromised object should be kept in a box or deep tray so that the container rather than the work of art may be handled for study, transport, or storage.

STORAGE AND TRANSPORT

The same environmental considerations for display must be applied to the areas in which lacquer is stored. Although lacquer itself is poisonous and impervious to insect attack, the substrate material may be vulnerable, thus routine cleanliness is essential for storage areas. Air filtration is necessary to avoid the buildup of dust and particulate matter. A regular program of dusting using a clean soft brush, such as a hake brush, should be carried out under the supervision of a conservator. Objects should not be stored near air-conditioning ducts or ventilation units. They should be covered to protect from light, which must be shielded with UV filters and turned off or kept at very low levels when personnel are not in storage areas.

When not on display, lacquer objects should be kept in an individual light-tight, dust-free storage cabinet. Cabinets and shelving should be POWDER-COATED METAL, and only wood that does not emit volatile vapors should be used. Organic acids from many woods will attack the metal inlays in lacquer objects.

Traditionally, lacquers are wrapped in a soft cloth of cotton or silk and kept in boxes made of paulownia wood. Paulownia wood readily expands and contracts with changes in humidity, thus acting as a good BUFFER by protecting the lacquer inside. If storage boxes are not available, the lacquer should be covered with soft, ACID-FREE paper (or a soft Japanese TISSUE) to protect it from light, dust, and inadvertent abrasion.

When transporting lacquer, only carts or trucks with rubberized wheels should be used. It is important to guard against crowding to avoid scratches and abrasions. These objects should be transported in individual wooden storage boxes. If there is no storage box available, they should be transported in padded boxes: these are handled rather than the work of art. Any unusual shapes should be supported with PADDING of soft acid-free tissue paper to stabilize them when stored or transported.

Suggested Reading

Webb, Marianne. *Lacquer: Technology and Conservation: A Comprehensive Guide to the Technology and Conservation of Asian and European Lacquer*. Oxford: Butterworth-Heinemann, 2000.

10. IVORY, BONE, AND ANTLER

Pete Dandridge

The chemical and physical properties of ivory, bone, and antler have made them appealing materials for artists and artisans given the ease with which they can be carved and polished when fresh, their high-tensile strength, and their beautiful, translucent white coloration. Not surprisingly, each has been utilized in almost every historic period and within many cultural groups to create discrete objects, inlays, parts of composite objects, or as a substrate or support for other media.

Ivory, bone, and antler are calcified tissues that share a similar composition: a complex PROTEIN scaffolding, or matrix, that is stiffened and strengthened by a mineral component. Collagen comprises at least 90% of the ORGANIC scaffolding, with other, proteins constituting the remainder. The collagen is typically arranged in ropelike, helical fibrils that form a closely packed and often interlinked physical structure that has an intrinsic bearing on its reactivity to the environment. The principal INORGANIC component is calcium phosphate, which, along with other calcium compounds, is secreted within the collagen framework.

Ivory, bone, and antler differ in their physical structures and their proportions of organic and inorganic components. Structural variations can also be found within a single object, and these differences can be reflected in their varying rates of reaction to environmental conditions. Having some sense of the physical and identifying characteristics of these materials can be helpful in determining how best to preserve them.

CHARACTERISTICS AND IDENTIFICATION

Ivory

Historically, ivory has been described as the mineralized tissue of elephant tusks. However, it is now understood that many different mammalian teeth and tusks served as the raw material for works of art, and given their chemical and structural similarity, the term has expanded to include the teeth and tusks of mammoth, hippopotamus, walrus, sperm and killer whale, narwhal, boar, and warthog. As illustrated in diagram 00, teeth and tusks structurally consist of an interior pulp cavity containing vascularized tissues and fine nerves, a core of dentine, a connective layer of cementum anchoring the tooth in the jaw, and an outer layer of enamel. Enamel (96% hydroxyapatite) is the hardest and most mineralized animal tissue, but the principal and most utilized component for works of art is dentine, material that is formed in successive layers, or lamellae, at the edge of the central pulp cavity. From this cavity, a microscopic structure of tubule radiates outward through the dentine and the cementum in a configuration that is unique to each species.

In the absence of gross morphological features such as size, shape, surface characteristics, and pulp or marrow cavity, it can be difficult to distinguish the teeth and tusks of different mammals and to differentiate compact bone and antler from dentine. There are, however, several unique identifiers that are visible with the naked eye. Both elephant and mammoth ivory can exhibit Schreger lines, an engine-turning pattern of intersecting arcs, the dentinal tubules radiating out in clockwise and anticlockwise direction from the pulp cavity. In mammoth ivory, the angle at which these lines intersect

is more acute than those in elephant ivory. The pattern is only evident in the transverse section of the tusk, thus visibility depends upon the orientation of the object and its working and finishing. Walrus tusk can be differentiated from other ivories by its two distinct layers of dentine, with the core layer displaying a “popcorn” structure.

Bone

Bone is comprised of collagen fibrils and mineral crystals of hydroxyapatite. Depending upon the bone’s function, the fibrils can be bundled together in multiple structures that are dense and compact, as found in the load-bearing long bones of the legs, or in more open, spongy, or cancellous structures such as the rib bones, which must have great tensile and compressive strength. These may appear alone or in combination, but are characteristically pierced by an elaborate system of blood vessels and canals. Bone will often have a pattern of darkened pits or striations across the surface where discolored organic material has been retained on the walls of the channels carrying blood. Whereas the lamellar structure of dentine can be evidence of a mammalian tooth or tusk, a layered structure is often seen in compact bone, particularly when the material is in a less well preserved state.

Antler

Antlers are carried by most members of the deer family and, with the exception of caribou and reindeer, are limited to the stags. They are formed each year in the spring with a period of rapid growth supported internally and externally by numerous arteries, and become necrotic and drop off in the fall after four months of growth. In cross-section, antler has an outer layer of compact woven bone and a spongy core of cancellous bone.

Vegetable ivory

Vegetable ivory is derived from the nuts of the Tagua palm tree. Unlike true ivory, these kernels of about one inch in length are comprised of CELLULOSE, are very white and hard, and have an indistinct pattern of concentric rings.

French ivory

Ivory substitutes have been manufactured in a variety of materials, including CELLULOSE NITRATE, casein, and various organic resins bulked out with a range of inorganic fillers. Synthetic ivory substitutes can be distinguished from ivory, bone, and antler by their varying fluorescence under ULTRAVIOLET (UV) light.

ENVIRONMENTAL CONSIDERATIONS

There are several factors that need to be emphasized in addressing the PRESERVATION and deterioration of artworks fabricated from ivory, bone, and antler. Among them are their openwork, porous structure, the presence of variable structures within an individual object (such as cancellous and compact bone, or dentine and cementum), and the

inclusion of both organic and inorganic components. Because of their openwork structure, they can be affected by fluctuations in RELATIVE HUMIDITY (RH). As moisture is absorbed or desorbed, the organic matrix of collagen will expand or contract, resulting in dimensional changes that differ in each orientation of the object—longitudinal, radial, and tangential. The resultant internal stresses are evidenced as cracks or splits between the laminations and by an overall warping. That same porosity also allows fluids or oils to be drawn into the body of the object.

The moisture that is often associated with burial environments can pose a significant threat to the physical integrity of ivory, bone, and antler. Depending upon the biological and chemical characteristics of the archaeological context, the collagen might have been entirely dissolved and leached out of the artifact, significantly compromising its physical integrity. Additionally, the residual openwork structure can allow minerals to be absorbed from the burial surroundings. Once excavated, these mineral SALTS will react with moisture in the surrounding environment. Each salt has a specific relative humidity at which it will dehydrate. The greater mass of the resulting crystals will generate internal stresses that can result in delamination, SPALLING of the surface, visible salt EFFLORESCENCE, and a general loss of cohesion.

To minimize dimensional changes in well-preserved objects and archaeological artifacts, ivory, bone, and antler should be exhibited and stored with relative humidity not varying more than 10% within a humidity range of 45–55% and temperature maintained at 68–72ºF. There are some objects that might require conditions at variance to these. As noted above, excavated material with little or no organic content may be relatively impervious to fluctuations in RH; however, these same objects might be susceptible to salt activity (cycles of hydration and dehydration), requiring their exhibition and storage in a more controlled environment with a narrower range of relative humidity. Portrait miniatures painted on very thin sheets of ivory (see Chapter 13) are prone to immediate dimensional response with changes in RH. Such fluctuations can endanger the adhesion between the substrate and the more dimensionally stable paint layer(s); thus these objects should not be exposed to more than a 10% fluctuation in RH while on display or in storage.

If the conditions within a gallery or storeroom cannot accommodate the required environment, a MICROCLIMATE should be created within a VITRINE, an object's frame, or in a closed, INERT box. The RH can be controlled with conditioned SILICA GEL, with either active or passive circulation of the surrounding air depending upon the complexity of the housing or exhibition.

Left in its natural state, ivory will slowly loose its original translucence, becoming more opaque and developing a warm, yellow-brown PATINA. Many cultures have adopted a particular aesthetic model for the appearance of ivory, bone, and antler, including the intentional bleaching out of the natural patina or the overlaying of the surface with multiple layers of polychrome. The interpretation of the original artistic intent can also be complicated by subsequent interventions in which the ivory or bone was coated with a gum or resin to reintroduce a degree of translucency or to stabilize an overlaying decorative surface. In addition, exposure of the object to excessive levels of UV and VISIBLE LIGHT might have caused the original, natural patina to lighten.

HANDLING

Our hands are a potential source of oils, salts, and moisture and should be isolated from absorbent materials like ivory, bone, and antler by wearing either powder-free nitrile GLOVES or clean cotton gloves. NITRILE gloves are more appropriate in instances in

which the object or its overlaying surface(s) might be susceptible to snagging or FLAKING caused by fibers or the open weave of cotton gloves. Structurally stable objects can be lifted with one hand supporting the weight from below its center of gravity, and the other hand stabilizing the object. Areas of the object with sensitive surfaces, such as polychrome, delicate extensions, and weak or damaged areas, should not be touched. Fragile objects or objects like portrait miniatures that readily respond to the heat and moisture generated by hands or breath should be lifted by a thin, rigid support, such as RAG BOARD or COROPLAST®, inserted beneath the object.

DISPLAY

While on exhibit, works of art made of ivory, bone, and antler should not be exposed to LIGHT levels exceeding 15 FOOT-CANDLES. It is possible that a secondary element associated with the object—for instance, an organic dye—will be more light-sensitive than the primary material, necessitating that its illumination be reduced further. All the lighting for these objects should be generated from outside the vitrine or within a vented light attic, and filtered to remove UV radiation. During examination and photography, any light exposure and its associated heat should be minimized.

All organic materials are susceptible to deterioration from VOLATILE ORGANIC COMPOUNDS (VOCs), which can be generated from the general environment or from materials used for storage and in the fabrication of a vitrine. These materials should be ODDY-TESTED to assure the creation of an environment that is as benign as possible. Additionally, any surface with which the object is in contact should be colorfast.

STORAGE

The same environmental guidelines for display should be enforced for storage. Within the 40–55%RH range, fluctuations should be limited to 10% and temperature to 68º±3ºF; however, light levels can be reduced to 5 foot-candles. For objects requiring more specific environmental levels, appropriately sized, materially stable, sealable containers can be made to accommodate both the work of art and conditioned silica gel. To minimize exposure to AIRBORNE dirt and dust, objects should be kept in closed drawers or covered with ACID-FREE tissue. Shelf-lining materials for storage units must be inert, fiber-free, and not generate a STATIC CHARGE. VOLARA®, an ARCHIVAL material suitable for drawer liners, can be isolated from an object with acid-free TISSUE or TYVEK®. If an object requires additional support, POLYETHYLENE foams of varying densities can be used with an acid-free INTERLEAF to minimize abrasion or grabbing (the catching and tearing of original material).

TRANSPORT

Objects made of ivory, bone, and similar materials should be transported within the museum by a cart or a padded, handled basket. It may be necessary to support the object with additional PADDING, such as FOAMS of varying rigidity and surface texture, bags filled with sand or glass beads, or wadded tissue. Any points of contact with the object should be isolated by materials such as acid-free tissue that have a “hard” surface but do not have loose fibers, an abrasive texture, or generate a static charge. No weight should be borne by fragile structural elements or delicate surfaces.

When objects are required to travel and could be exposed to significant variations in relative humidity or temperature, it is necessary to BUFFER the object and the crate or container to minimize such fluctuations. Dense organic materials such as ivory have the ability to be self-buffering within a contained space. For flat objects such as an ivory diptych, such a space can be created by wrapping them in a sheet of acid-free tissue and then inserting them into a close-fitting polyethylene bag or wrapping that can be sealed with TAPE. With more dimensionally complex objects, an initial packing box should be created to allow for the placement or insertion of shaped, high-density polyethylene foam blocks to fill open spaces or cavities. The box should then be wrapped and sealed with polyethylene sheeting. Wood, polystyrene, and other thermal insulating materials are then integrated into the shipping crate to minimize temperature gradients.

Suggested Reading

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11. PAINTINGS AND FRAMES

Michael Gallagher

The proper care and handling of paintings and frames is mostly a matter of common sense. A thorough knowledge and understanding of the basic factors that can affect and/or damage these works, combined with a considered and patient approach, will normally be sufficient to guarantee an object's safety during handling, storage, and display. Nevertheless, it should be acknowledged that it is not possible to provide absolute guidelines for every situation, and there is no substitute for expertise born of experience and specialist training. Faced with an unfamiliar problem, or if ever in doubt, the best course of action is always to seek advice before taking action.

ENVIRONMENTAL CONSIDERATIONS

RELATIVE HUMIDITY (RH), temperature, and LIGHTING are environmental factors that can have a huge impact on the present and future condition of an artwork. Paintings are composite objects constructed from a variety of materials that will behave differently and independently from one another when there are pronounced fluctuations or extremes in environmental conditions.

Relative humidity (RH)

Relative humidity is particularly important as many of the materials in paintings are hygroscopic, potentially undergoing dramatic dimensional changes if there is a marked increase or decrease in the moisture content of the air. Depending on a complex variety of factors, including the scale of the work, its general condition, and previous conservation treatment history, inappropriate RH can lead to serious damage: surface deformations from the tightening or slackening of canvas; expansion or shrinkage, opening of joins, or the formation of cracks or splits in wood supports; and FLAKING of the paint layer. Prolonged elevated temperatures and high humidity promote the formation of mold; heat can cause a range of reactions, including distortions and flaking of the paint layer; sudden changes of temperature may cause condensation on the surface of a painting; and very cold conditions (below 40°F) can result in the cracking of acrylic paints, which become extremely brittle at low temperatures.

To avoid these problems, a stable environment is ideal for the long-term PRESERVATION of paintings and frames. Display and storage areas should be maintained at an optimum RH of 45–55% and a temperature of 68–72°F (20–21°C), and paintings should never be hung or stored near any source of heat, including heating vents and radiators.

Lighting

Appropriate lighting is also an important factor in preserving and protecting paintings. High light levels, and particularly the presence of ULTRAVIOLET (UV) light—the most damaging part of the spectrum—can encourage the deterioration of a wide variety of materials, including pigments, binding media such as oils and acrylics, and natural and

synthetic varnishes. These risks are not confined to DAYLIGHT alone but include FLUORESCENT and INCANDESCENT gallery lighting, photographic lamps, and VITRINE and case lighting, which can also produce dangerously elevated temperatures and create hazardous MICROCLIMATES.

The choice of type and level of lighting for gallery and storage areas is very much a matter for the museum lighting specialist and the conservator, as factors such as the length of exposure and the sensitivity of the artwork can vary enormously. The reactivity of paintings to UV and visible radiation varies considerably and is dependent upon the pigments, binding media, and the presence or absence of varnish. Illumination should never be excessive, and UV should always be excluded by the use of appropriate GLAZING or filters. If a painting is to be exhibited in NATURAL LIGHT, UV-filtering film should be in place on the windows. For additional protection, UV-absorbing laminated GLASS or nonreflective ACRYLIC SHEETING for framing is recommended. In general, for display purposes, it is advisable not to exceed 15–25 FOOT-CANDLES. At all times, paintings must be protected from direct sunlight, from other sources of illumination that contain UV, and from the radiant heat of artificial light.

HANDLING

A fundamental principle in handling paintings on canvas or wood panel is that nothing should ever touch the paint surface. Paintings are at their most vulnerable when being handled, and some of the worst damage can occur during a relatively simple process such as removing a painting from a wall, carrying it between rooms, or placing it in temporary storage. An understanding of the potential risks and taking the appropriate measures to avoid them can minimize minor mishaps and prevent major catastrophes.

It is important to be aware of the potential hazards to a paint surface or frame posed by jewelry, watches, and ID badges, all of which can scratch and abrade.

No more than one painting should be handled at a time, and generally it is better to carry the painted surface facing the handler. Small pictures may be safely carried by one person, but heavy or larger works will require two or more. It is worth remembering that what may appear to be a relatively small painting may in fact be very heavy if, for example, it is on panel and glazed, and should therefore be handled accordingly. An unframed panel can be very fragile. The reverse must be checked to see whether or not it is reinforced with a supporting structure. If a painting is to be stored temporarily, it is advisable to stand it on the end grain and lean it against a wall.

Fig. 1 Framed paintings should be carried with two hands, one at the side and one at the bottom.

Frames afford some protection, and a painting is safer with a frame than without one. A painting should never be lifted by the top of the frame or stretcher but rather supported with two hands, one at the side and one below **(Fig. 1)**. For very large works, this may require several people, to spread the weight and prevent torque. Whenever a team of people is involved in handling, it is essential that the course of action is agreed upon in advance and that everyone is aware of their role.

It is safer to carry a painting in its frame, but care must be taken to avoid damaging the frame itself in the process. The condition of the frame should be assessed prior to handling, checking for old breaks or repairs. It should only be held along secure areas of carving or molding, and vulnerable projecting areas of ornament should never be grasped. One should also be aware that wood tends to shrink across the grain on aging. In frames, this will cause mitered joints to open on the inside. Open miters do not necessarily indicate instability. Many frames have a backing structure or splines that keep the corner joint strong even when the miter opens.

Large modern canvases can present special problems, as they may only have strip frames or no frame at all. In such cases, it may be necessary to handle the painting by its edges and/or the stretcher (the wood framework over which the canvas is stretched). Great care must be exercised not to insert the fingers between the stretcher and the reverse of the fabric support, as this may eventually cause cracks in the paint film that only become visible after several months. Additionally, unpainted, unvarnished, and porous portions of the surface are vulnerable to staining from oils and dirt on fingers and hands. Clean, thin cotton GLOVES will prevent this, though it should be noted that these may not provide a sufficiently secure grip for particularly heavy paintings, thus NITRILE gloves may be preferable.

At no time should anyone but a conservator touch the painted surface or the back of a canvas—not even for the removal of dust; pressure of any kind may disturb the

paint surface. No attempt should ever be made to clean or otherwise treat a painting. *Neglect is less dangerous that inexpert treatment.* If there is any doubt about the condition of a painting, or if it has been damaged accidentally, it should be left untouched until it can be examined by a conservator. Any damage, however slight, should be reported. If paint flakes or parts of frames become detached, and it is necessary to move any fragments, all the pieces should be carefully collected and saved. Repairs are much easier if these are available. All damage should be documented with notes and, if available, digital images.

FRAMING, HANGING, AND DISPLAY

Fig. 2 Brass mending plates should be used to secure a painting in its frame. Those with two holes help prevent the bracket from shifting.

Although only conservators are responsible for framing procedures, it is important that technicians, curators, and others who have direct contact with these works understand how a painting is secured and protected in its frame. The security of a canvas in its frame ideally should never depend on nails, which can easily work loose and fall out. It is preferable to use metal brackets bent so that when one end is screwed to the frame, the other end will press against the stretcher **(Fig. 2)**. When framing panel paintings, flexible spring clips are used to allow for eventual expansion and contraction as well as convex flexing during humidity changes. Panels can be secured more safely on the end grain, but a flexible material, such as cork or ETHAFOAM®, should be used in the rabbet across the grain to adjust the space between the painting and its frame if the latter is too large.

A painting should be held in its frame so that the edges of the paint surface cannot be chipped or abraded. To facilitate this, the rabbet may be lined with strips of ADHESIVE felt. Adjusting the stretcher keys and removing objects that become wedged between canvas and stretcher should be undertaken only by a conservator.

Labels should not be applied to the backs of canvases. They may cause the area of fabric to which they are attached to expand and contract at a rate different from that of the rest of the canvas, possibly resulting in cracking, flaking, or swelling of the area on the corresponding paint surface; additionally, the materials in the adhesive can seep through the canvas and adversely affect the paint layer. A BACKING of a rigid or semi-rigid material such as FOAMCORE will protect the painting from blows to the reverse and from dust, as well as slow down its response to environmental shifts. Backings should be fitted to the frame back or the stretcher using only a few screws around the perimeter to allow for gradual air exchange. Small holes should not be cut in the backing, as the focused and uneven air exchange can accelerate mechanical damage in the paint layer such as localized cracking and/or flaking.

When hanging a painting, it is vital that all supporting wires and fixtures, as well as the display wall or surface, are strong enough to bear the weight. During the hanging procedure, it is essential that everyone involved understands the process and their role. This is especially important with large and heavy works, when specialist hydraulic equipment may be required.

Ideally, screw eyes and dangling wires should be removed from the frame as soon as a picture is taken from the wall, since screw eyes can damage the surface of other frames in a stack, and dangling wires can easily scratch a paint surface as well as cause injury to handlers. If it is not practical to remove these fittings, wires should be neatly rolled and secured with ties or in a small PLASTIC BAG fixed to the reverse of the frame.

STORAGE

Improperly stored paintings are potentially much more vulnerable to accidental damage than works on display. Paintings sitting on the floor or leaning against one another are easily scratched or punctured. Therefore, whenever possible, paintings in storage should be hung securely on racks. Modern works, which frequently have exposed areas of fabric support and delicate, unvarnished surfaces, should always be covered in storage with smooth ACID-FREE paper, such as GLASSINE, to protect them from abrasion and surface dirt. Care must be taken whenever glassine is used, as its cut edges are sharp and can cause damage to a picture surface; its cut edges must not come in contact with the paint surface. Glassine must be lifted and not dragged across the painting. For long-term storage, it is good practice to construct travel frames for particularly vulnerable unframed works. This decision and the design and fitting of the frame should be discussed with a conservator.

In storage, air circulation is necessary to avoid mold. To protect paintings from dust, light cotton covers may be used, if necessary. PLASTIC SHEETING in direct contact with the work of art is not recommended because of the risk of condensation developing on the inside of the PLASTIC should there be a rapid drop in temperature. Because dust is a source of ACIDITY, it is important that routine housekeeping take place in storerooms containing paintings. Paintings should not be stored near air ducts and vents, or in active passageways.

In both gallery and storage areas, it is important to be alert to INSECT INFESTATION in frames and wood panels. FRASS, sharp-edged and bright whitish worm holes, live insects, and insect casings should be brought to the attention of a biological specialist. Infected works should be isolated from other objects, wrapped in plastic, and TAPED while awaiting treatment.

Stacking and protecting unframed paintings

The stacking of paintings and frames by leaning them against each other on trucks or in storerooms is inherently risky, as both the frames and painted surfaces can be damaged. If stacking is truly unavoidable, it must be done with the utmost care. No more than three paintings should be placed in any stack, and all the pictures in a stack should be of similar size. Paintings and frames should be stacked upright face-in, never laid flat, and PADDING such as low-density Ethafoam® must always be inserted between each item at the corners and wherever there is projecting ornamentation. Sheets of ACID-FREE BOARD may also be inserted between stacked paintings for additional protection, but it is essential that the padding or separating material never come in contact with the paint surface.

Sufficient and appropriate padding should also be present beneath the paintings standing against gallery or storeroom walls. High-density Ethafoam® or felt pads with RUBBER skidproof bottoms are suitable for this purpose. Heavily ornamented frames can be temporarily supported on CARPET-covered wooden blocks. Care should be taken when placing these supports to avoid damaging the frame ornament. Depending on the type of storage area, it may be appropriate to label stacks to ensure that people are aware that a work of art is being stored and that they should exercise due care and attention. However, to avoid all chance of slippage or accidental damage by a passerby, it is best practice to hang pictures on gallery walls or storeroom racks as soon as possible.

TRANSPORT OF PAINTINGS

It is generally best to move paintings on padded side trucks rather than by hand. The truck should have a padded floor with a lip along the front and back, and care should be taken not to overload it. The structure of the truck must support at least two-thirds of the height of the painting to prevent the risk of toppling, and great care must also be exercised to prevent anything coming into contact with the reverse of a canvas, as this will cause surface distortions, induce cracking, and may even result in a puncture or tear. Very large paintings may need to be placed on their longest side, but if a painting is substantially wider than the truck, a piece of lumber should be firmly attached to the top bar of the truck to support both stretcher and frame.

Fig. 3 Cotton straps should be used to secure a painting to a side truck. Points of contact should be padded with a soft material.

The painting should be carefully secured to the truck with woven cotton STRAPS, padding all points of contact, and avoiding any direct contact with the painted surface **(Fig. 3)**. The frame should be protected from potential abrasion with appropriate soft padding, paying special attention to avoid putting pressure on vulnerable areas of ornament.

Suggested Reading

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12. WORKS ON PAPER

Marjorie Shelley

"Works on paper" encompass a very diverse and often complex group of materials ranging from Western drawings, prints, and pastels to South Asian paintings on palm leaf, from medieval parchments and miniatures on ivory to drawings on papyrus and graphic art on silk. Structurally, these objects consist of a substrate, or support (paper, parchment, papyrus, palm leaf, ivory, silk), and a design, or media layer, comprising any pigmented or colored substance that can be brushed, drawn, or printed, as well as binders and adhesives. Because these objects are predominantly ORGANIC (naturally or synthetically derived from plant or animal sources), they are readily damaged by adverse environmental conditions and contact with ACIDIC materials, and their physical structure makes them highly vulnerable to poor handling. While they differ in composition, they each have similar care and handling requirements.

ENVIRONMENTAL CONSIDERATIONS

Temperature and relative humidity (RH)

Storage and display at a temperature of 70°±2°F and RELATIVE HUMIDITY (RH) of 50%±5% are fundamental to preserving paper- and parchment-based materials. Because these substrates are hygroscopic and thus expand and contract with variations in atmospheric moisture, extremes and fluctuations in these conditions must be avoided. High RH (above 65%) will provoke undulations, delamination, tearing, softening of gum coatings, and bleeding of colorants. In the presence of acidity, high humidity encourages mold growth, insect activity, and staining. A dry and hot environment, or localized heat from tungsten HALOGEN bulbs and sunlight, will accelerate chemical reactions, embrittle and degrade CELLULOSIC and PROTEINACEOUS structures, desiccate adhesives and binding media, and provoke FLAKING in the paint layer. A rapid drop in temperature may cause condensation on the inner side of the GLAZING, water damage of a framed object, and FUNGAL growth on the work of art. To avoid chemical and physical damage, storage and display locations should be monitored at all times using digital or RECORDING HYGROTHERMOGRAPHS. An object that requires a narrow climate range for its PRESERVATION should be kept in a MICROCLIMATE, an enclosed box, frame (see below), or VITRINE incorporating conditioned SILICA GEL or other BUFFERING MATERIAL that will maintain the desired RH by the gradual release and absorption of MOISTURE VAPOR. When paper or parchment are exhibited in the same vitrine with other highly sensitive material, RH levels should favor the more vulnerable object.

Air quality

Air conditioning, filtering systems, good ventilation, VACUUMING, and routine cleaning can limit the amount of dust, soot, and other particulate matter that settles on these objects, and will keep storerooms and galleries clear of acidic and oxidizing gases. Storage or exhibition in cases or galleries recently painted or constructed should not house objects for at least three weeks prior to use, to prevent damage from off-gassing of deleterious vapors (VOCS) such as formaldehyde, sulfur, and nitrogen oxides. Such pollutants can

stain, physically degrade, and promote color alteration of organic materials, blacken lead pigments, and TARNISH silver leaf. Similarly, office copiers that emit ozone, which will fade colorants, should be kept far from cellulose- and protein-based materials and SYNTHETIC polymers. Appropriate storage materials (see below) will also provide protection from poor-quality air.

Light

Deterioration from visible and ultraviolet (UV) LIGHT is cumulative and irreversible. Limiting light exposure, controlling the type of light, its intensity, and the duration of display are essential to preventing vulnerable natural and synthetic pigments and dyes from fading, and to protect works on paper and related materials from embrittlement. Loss of color is a slow process and generally not perceived until the damage is done. The following guidelines should be followed:

Fig. 1 Light meter held parallel to the displayed work on paper.

- Light levels should not exceed 5 FOOT-CANDLES (measured with a LIGHT METER), **(Fig. 1)**, and display periods should be restricted to three months. The frequency of exhibition—be it once a year or once every three years—must be determined on a case by case basis. Rotating works on view is a standard museum practice for limiting light exposure of individual objects.
- Periods of darkness will not reverse fading or other light-induced damage, but storage in darkness will help maintain the object's current condition.

- Reducing the amount of ULTRAVIOLET light can be substantially achieved with UV-filtering ACRYLIC SHEETING, UV-laminated glass, and LED illumination. UV light, present in natural and artificial light, is the most damaging part of the spectrum and, for most paper-based objects, does not enhance illumination for viewing. FLUORESCENT LIGHTING, often used in workrooms, should be shielded with polycarbonate UV sleeves. DAYLIGHT should be avoided, but when windows are present, UV film applied to glass and additionally blocked with UV shades will significantly reduce this damaging light source.
- Restricting unnecessary exposure to light: Works of art that are not in SOLANDER BOXES or folders, such as framed drawings in storerooms, those awaiting gallery installation or dismantling, and objects not being actively studied, should be covered with KRAFT PAPER or other BARRIER MATERIAL, and labeled to avoid unnecessary handling. Light levels should be reduced or turned off in storage areas when personnel are not present.

Biodeterioration

Cellulosic, gum, and protein-based substrates and media provide nutrient material for biological activity. Worm holes, GRAZING, FLYSPECKS, larvae, casings, and FRASS are evidence of insects; FOXING (irregular circular reddish-brown marks) and fungal growth (white or colored fibrous molds) are signs of BIODETERIORATION. Antique frames, in particular, must be examined before installation to ensure that they are free of these contaminants.

Preventing biological damage requires a vigilant eye and maintaining stable RH levels, constant air circulation, routine vacuuming and dusting to eliminate moisture-absorbing particulate matter, and tracking insect activity. An INTEGRATED PEST MANAGEMENT (IPM) program should be followed to effectively address these issues.

Storage, work, and display areas should never be in proximity to sinks and overhead water pipes, and food, drink, and plant material should be off limits. There are presently no known safe chemical FUMIGANTS for works on paper. All infested material should be isolated by wrapping in ACID-FREE tissue, then enclosing in POLYETHYLENE sheeting or bags sealed with TAPE. Infestation should be brought to the attention of a conservator and biologist for ANOXIC TREATMENT or another means of eradication. (See Chapter 20 for a discussion of pest management.)

HANDLING

When preparing to handle paper-based and -related materials, one must be alert to situations that will provoke damage. All jewelry and ID cards must be removed. Clean, dry hands without lotion will limit the transfer of soil and acids. GLOVES are generally not worn when handling these objects because they diminish tactile sensation, thus requiring additional manipulation; however, NITRILE or clean cotton gloves should be used for metal frames, delicate book bindings, and coated papers to avoid etching and staining from skin oils. Notes should be made in storage boxes or on wrapping materials to alert handlers to sensitive materials. Work surfaces should be clean and free of debris. Metal clips and staples, which can puncture, should be avoided, and pencils should be used for note taking. These safety procedures should be followed by study-room visitors as well as by staff.

While the vast number of artworks in this category are in good condition, many have been compromised by the constituents of the support, unstable media, poor environmental conditions, contact with acidic housing materials, or carelessness. Before handling, the object's condition must be methodically assessed in order to plan the best procedure. Handling of an unmounted work of art can be limited by supporting it on a BLOTTER, sheet of RAG BOARD, or other rigid material. The paper or other substrate layer should be examined for tears, creases, folds, losses, and discoloration. The sites of attachment to the backing should be noted. The design layer should be checked for flaking paint and breaks from CORROSIVE pigments. Repairing or unfolding a brittle support should never be attempted; inexpert work and improper materials may worsen the condition. Touching areas of weakness should be avoided and damage reported to a paper conservator before continuing any course of action. Any accidents should be documented and photographed.

Fig. 2 Lifting an unmatted work on paper by inserting a card beneath an edge

Fig. 3 Supporting an unmatted work on paper

To lift an unmounted work on paper **(Fig. 2)**, one must not grasp or hold the object by its corners or edges, as these are likely to be its weakest sites. A thin piece of paper or micro-spatula can be gently inserted beneath the object's edges to determine where it is adhered to its backing. If it is not attached, one can slide either blotting paper, two-ply rag board, or ACID-FREE corrugated board beneath it. These secondary supports, not the work of art, will serve as the means of handling and transport **(Fig. 3)**. Because parchment and ivory respond rapidly to the warmth and moisture of the hand, they should be transported in a similar manner or placed in a shallow tray lined with rag board or FOAM sheeting (see Chapter 13). Papyrus and palm leaf should be supported with smooth-surfaced, nonfibrous materials on a semi-rigid underlying layer, as this will not snag and dislodge fragments or fibers.

Fig. 4 Turning an unmounted work of art by placing it between two sheets of rag board

To reverse or turn over an unmounted work **(Fig. 4)**, one can place a secondary support beneath the object as described above, then place another rag board sheet above it and turn the “sandwich” over; the new top piece should be slowly lifted to expose the VERSO that now faces up. Extremely brittle and torn papers, large pieces of papyrus, and compositions in gouache, tempera, chalk, charcoal, and pastel with flaking or powdery media, or densely painted surfaces (Indian miniatures, medieval manuscripts) should be turned over only by a conservator.

Fig. 5 Protecting the front of a hinged and matted work on paper for viewing the verso

To view the verso of a matted object **(Fig. 5)**, the work of art should never be lifted through the mat window; rather, the mat should be opened on a table. A sheet of GLASSINE should be placed in the area corresponding to the extended open sheet (while taking note if the object is hinged at the top or along the left edge) to protect the front of the sheet when it is face down. The work of art is then carefully turned onto the glassine to expose its verso. Only a conservator should handle the work of art that is partially or fully adhered to a backing, or if its hinges do not have full flexibility.

Fig. 6 Unframing a work on paper

To unframe a work **(Fig. 6)**, it is essential to first remove dust, paper debris, nails, and other hardware from the frame backing. All labels, or the entire backboard, should be saved, as these may be of historical importance. One should never attempt to pry apart backing layers. Instead, the framed "package" should be placed on a table with the work of art and glazing face up, then these layers gently pushed down while carefully pushing the frame upward to separate and remove it. To enable the hands to glide beneath the frame, this procedure may require elevating and inserting foam blocks beneath the assembly. Once the frame has been taken off, any blocks may be removed and the individual layers carefully separated, beginning with the glazing. The glazing should be turned away from the work of art, as if turning the cover of a book, to protect the work should the glass break. If the work of art is adhered to the glazing or stuck to the backboard, this should be brought to the attention of a paper conservator. Pastels, papyrus, and miniatures on paper or vellum are extremely fragile and should not be turned face down. A conservator or experienced technician is required in all instances to unframe and unmount them.

STORAGE AND DISPLAY MATERIALS

All materials proposed for the display or storage of artworks in this group, such as matting material, coverings for book cradles, and vitrine fabrics, must be acid-free and ODDY-TESTED to determine that detrimental constituents are absent.

Matting

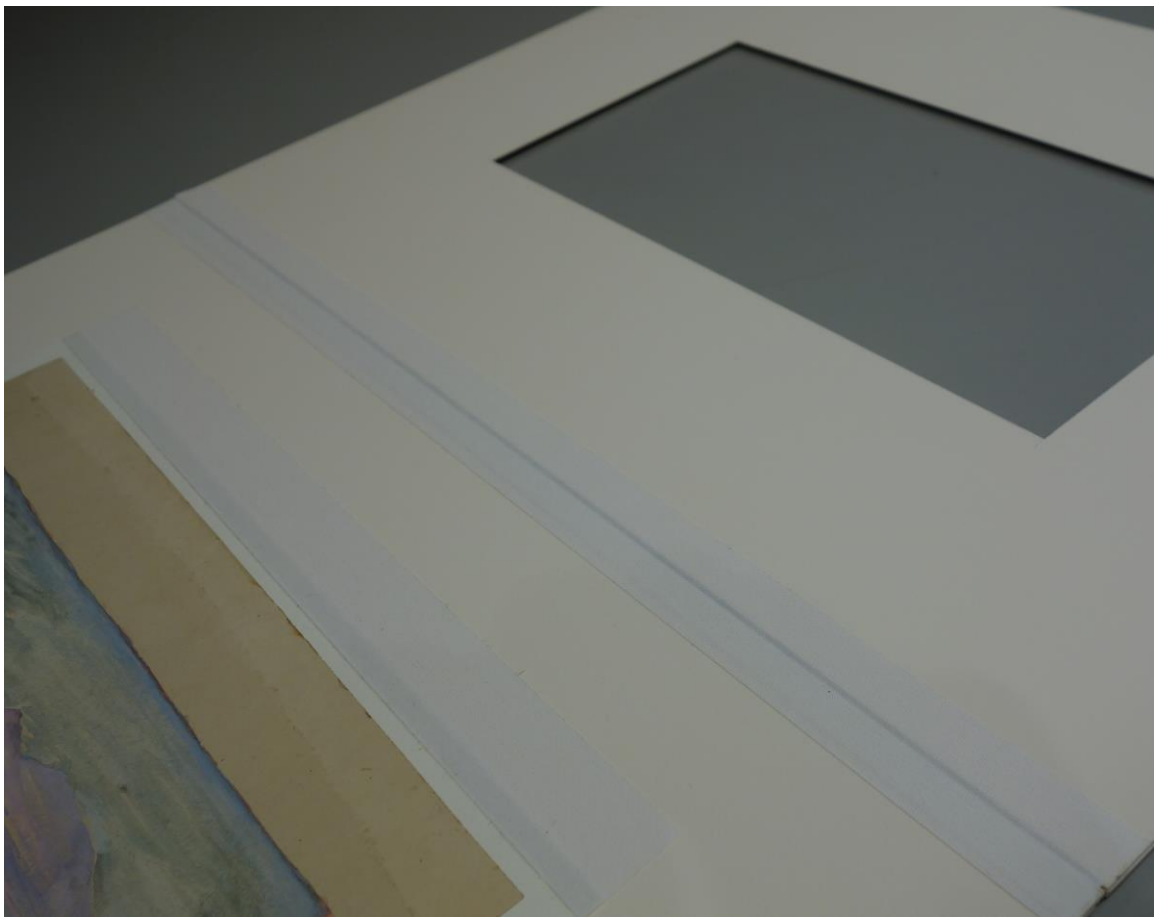

Fig. 7 Mat window and backboard joined with acid-free or gummed tape

A mat consists of a window layer, which protects a framed work of art from contact with the glazing, and a backboard joined along the inner left edge by moisture-activated GUMMED CLOTH TAPE **(Fig. 7)**. Matting for display and storage is one of the most important preservation measures for these objects, and only 100% acid-free and lignin-free rag board should be used. Yellowed and degraded mats should be replaced. MYLAR® and other storage folders have a STATIC CHARGE that damages paint and tears paper, and should never be used to store works on paper without the advice of a conservator.

Hinging

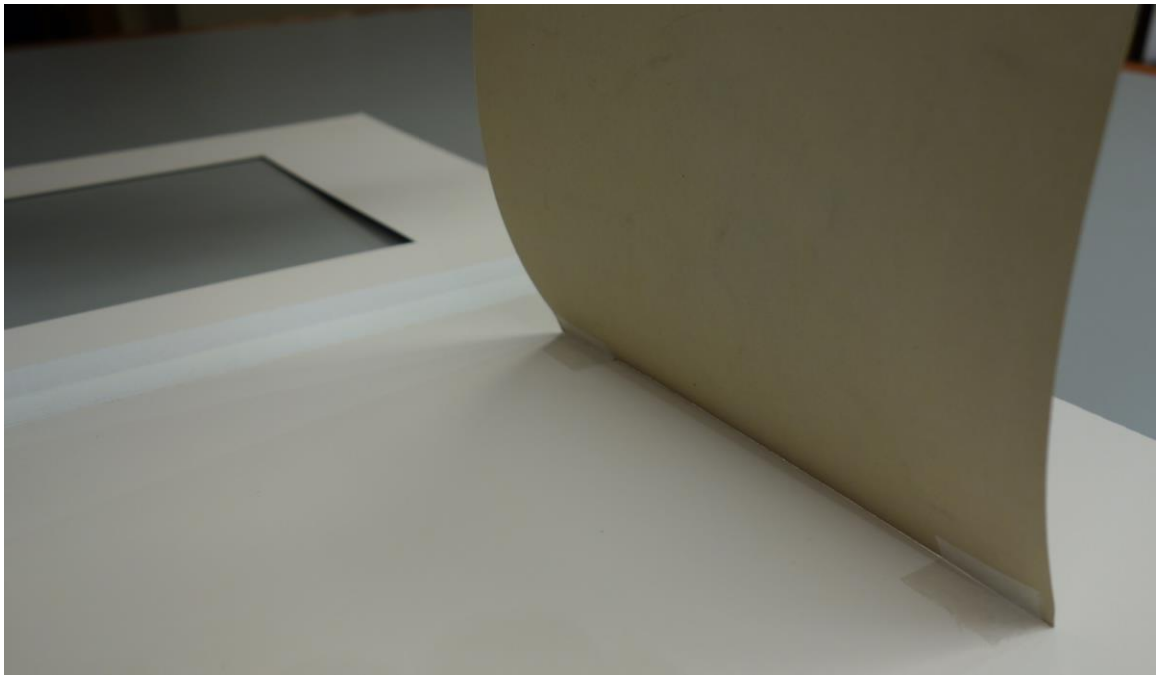

Fig. 8 Hinges made of folded Japanese tissue to attach the artwork to a backboard

The verso of the artwork is secured to the mat backboard with Japanese TISSUE hinges **(Fig. 8)** adhered with WHEAT STARCH PASTE, a reversible ADHESIVE that requires frequent preparation and refrigeration, or with photo-corners made of ARCHIVAL or glassine paper. Pressure-sensitive tape, PVA adhesive, glues, RUBBER cement, dry-mount tissues, and other commercial products will provoke degradation and staining, and thus must not be used.

HINGING is a complicated procedure requiring assessment of the object's dimensions, weight, translucency, vulnerability to staining, and the presence of inscriptions on its verso. Such factors determine the method, the type of Japanese paper to be used, and the site of their attachment; for example, Islamic paintings originally contained in albums are often hinged along the left of the verso to enable reading the text on the back. Improper hinging methods can cause staining and undulations. References in the reading list offer detailed instructions for this procedure.

Glazing

To protect from physical and environmental damage, works in this category are always glazed with GLASS or ACRYLIC SHEETING for display, storage, and travel. The properties of the design layer will determine the type of glazing. Powdery media (pastel, charcoal, chalk, soft graphite), flaking gouache, and very thin papers are glazed with UV-laminated glass, which does not generate a static charge, or with ANTI-STATIC UV acrylic sheeting. Ordinary picture glass does not filter UV and easily shatters. Standard UV acrylic sheeting for stable media must be cleaned in advance of framing with an anti-static cloth or solution. Glazing should be cleaned before a work is framed using an agent specified for glass or acrylic. For framed works, liquids must be first applied to lint-free cloth (such as KIMWIPES®), then applied to the glazing, and thoroughly dried. Liquid should never be

applied directly to glazing on a framed object, as it may seep into crevices, staining the mat and the work of art. Acrylic sheeting on framed objects should only be lightly rubbed when cleaning to avoid generating a static charge, which will provoke flaking and lift thin sheets of paper.

Framing

To prevent the migration of acidity to the mat or work of art, the interior surfaces of wood frames (rabbets) should be lined with rag board or POLYESTER-acrylic frame sealing tape. The frame backboard must be acid-free and sealed against dust. Framed works requiring a specific RH range for display, storage, or transit should be contained in a microclimate to prevent the transfer of air. This consists of a glazing layer, the matted work of art, a conditioned buffering sheet (such as ART SORB®), followed by a MOISTURE BARRIER (such as MARVELSEAL® or acrylic sheeting) and the frame backboard. The entire package is then sealed with barrier tape (such as polyester or MarvelSeal®) to maintain the desired internal conditions.

Book structures and albums

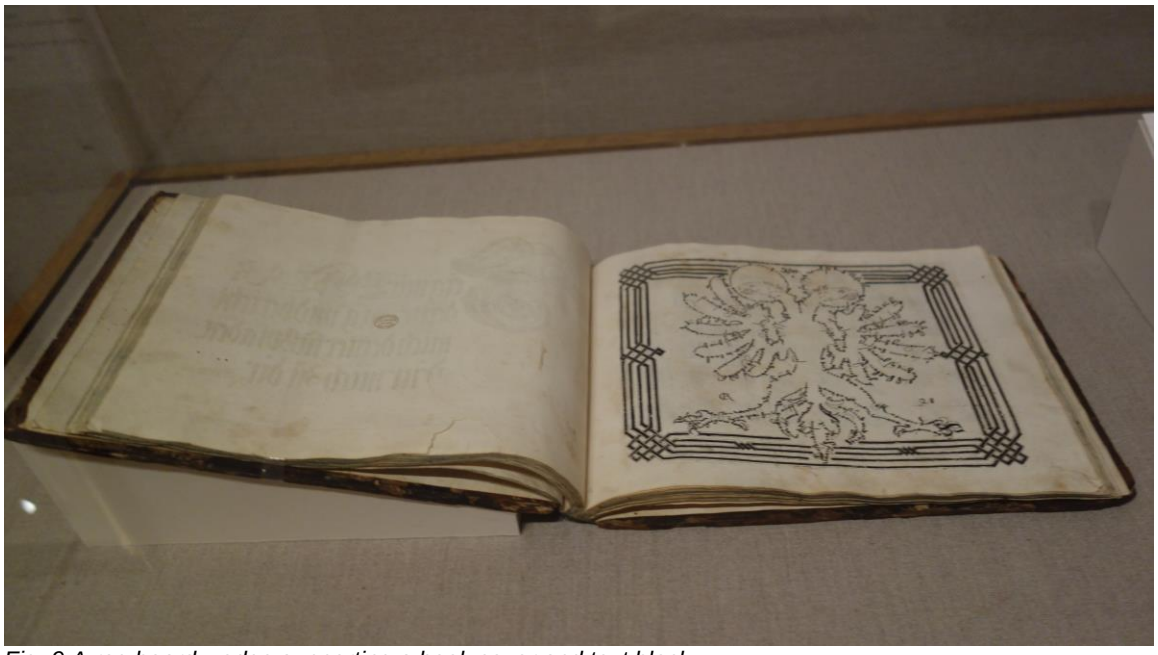

Fig. 9 A rag board wedge supporting a book cover and text block

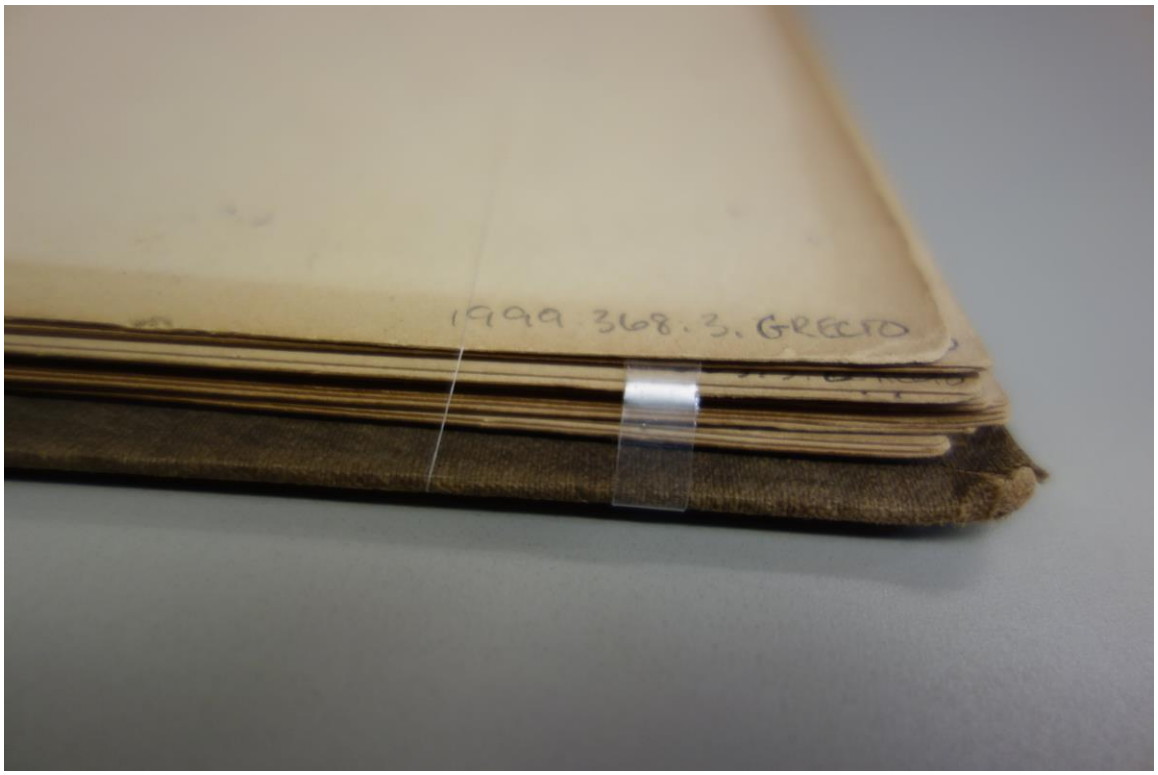

Fig. 10 Book strapping: transparent polyethylene and hair silk

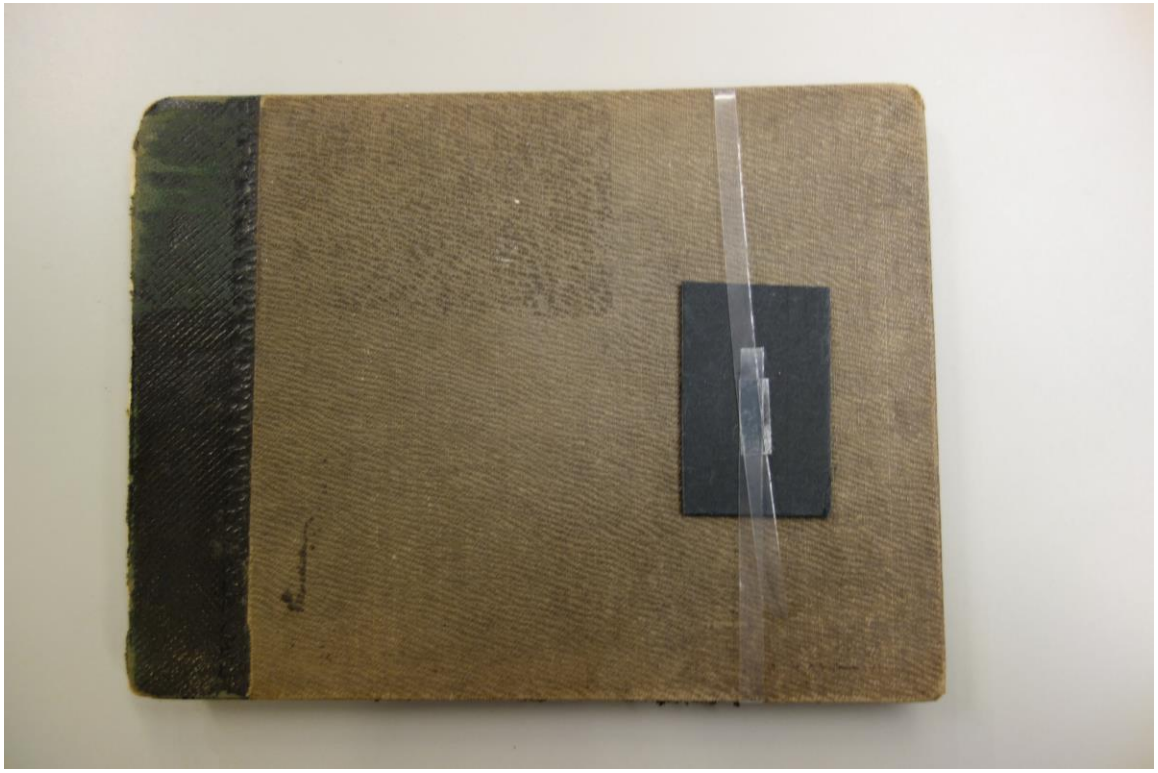

Fig. 11 Protective paper inserted between the book cover and strapping tape ends, the latter secured with adhesive tape

Albums of drawings or miniatures are supported for display on book cradles, or with WEDGES beneath the open covers **(Fig. 9**; see Chapter 15). The thickness of the text block on each side determines the angle of opening of the cradle, or the size of the wedge beneath each cover. These supports should be the same size as the book cover. Wedges can be made of foam or constructed of rag board, and cradles of rag board or acrylic sheeting. Open books are secured on each side of the text with soft POLYETHYLENE STRAPPING TAPE to hold the bulk of the text block, and/or hair silk to hold an individual page **(Fig. 10)**. The strap ends are joined at the back of the cradle wings with acid-free tape; if a cradle is not used, thick paper must be inserted between the back of the cover and the tape to avoid damage **(Fig. 11)**.

Housing

Ensuring that these objects are housed in acid-free materials, protected from adverse climate and excessive light, and subject to minimal handling is fundamental to preservation.

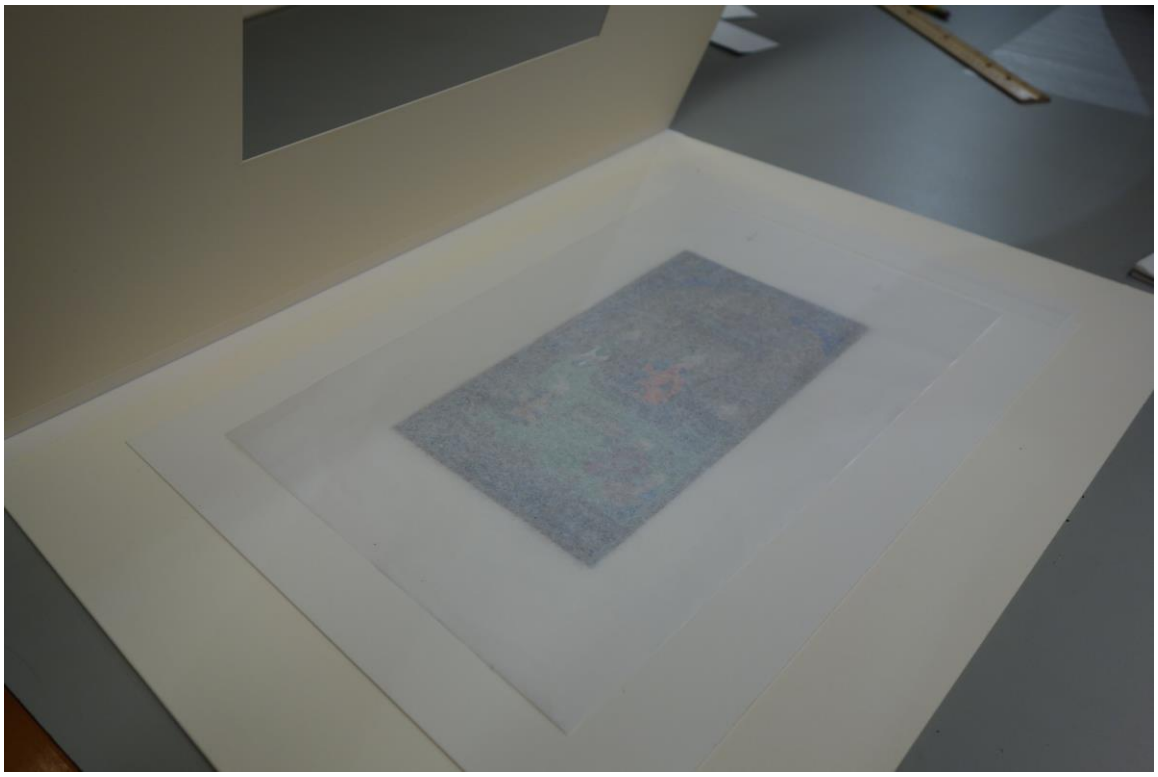

Fig. 12 Interleaving material on a matted work on paper

Fig. 13 Mylar® window on the inner side of the outer mat window

Cellulose- and protein-based works of art should be stored in chemically INERT archival boxes or folders, sealed frames, or POWDER-COATED METAL cabinetry. They should never be stored in WOOD or COMPOSITE WOOD cabinets, or in folders, mats, or boxes made of unprocessed wood pulp. The volatile gases (VOCs) these materials emit and the acidity of low-grade paper products and many adhesives will accelerate deterioration. Housing made of 100% acid-free buffered and UNBUFFERED papers will mitigate acidity in the immediate environment and moderate changes in atmospheric conditions. Additional protection for works in storage is provided by acid-free INTERLEAVING material (such as glassine and unbuffered tissue) placed on the face of the artwork **(Fig. 12)**. For matted objects prone to flaking (such as gouaches, chalk drawings, pastels, and South Asian miniatures), interleaving is placed between a two-layered mat window. For stable paint layers and thick supports, clear polyester film (Mylar®) is adhered with acid-free tape to the inner top window of a multilayered mat **(Fig. 13)**; its transparency minimizes handling by allowing immediate viewing of the artwork. Opaque buffered tissue is detrimental to some pigments and should not be placed on the object's surface without the advice of a conservator, but is suitable as a barrier between the back of the artwork and its mount. Any interleaving should be lifted, not dragged across an object, to avoid scratching the paint or printed layer.

Fig. 14 Solander boxes for storage of matted and unmatted works on paper

Matted works are stored face up in Solander boxes, which are air-, dust-, and light-tight and thus offer excellent environmental protection **(Ch. 12 - fig. 14)**. Standard-size mats kept in Solander boxes of corresponding dimensions allow for safe, movement-free storage. Matted works of different sizes are organized in storage boxes with the largest at the bottom graduated toward the smallest and separated by sheets of rag board corresponding to the interior dimensions of the box. Frame sizes are similarly standardized to correspond to mat dimensions. Storage boxes are also used for housing unmatted works on paper and parchment, albums without slip cases, and individual unframed pastels. Unframed large-format works on paper are housed in folders made of thick ACID-FREE PAPER. Stacking should be avoided when possible, but when a matted or unmatted work is removed from a stack, this should be done by lifting all the objects above it, not by pulling it out from its place.

Permanent framing is advisable for pastels, fragile media, and works requiring stabilized relative humidity. For storage, these objects should be shelved face up, or on a stationary rack with a labeled opaque paper or fabric cover to block light. Movable racks should not be used for framed objects with fragile media because vibrations will dislodge weakly held paint. Shelving should allow safe access to stored works.

TRANSPORT

Solander boxes, stacked mats, folders, and trays with portrait miniatures or small framed works are transported horizontally within the museum on carts with maneuverable, cushioned wheels. Powdery media always travel flat and face up.

Large framed works on paper generally require two handlers. To prevent torque, they should be handled at diagonally opposite corners or midway along opposite edges.

These works are moved on side trucks and should be secured to it by strapping. When stacked, they should be separated with CARDBOARD or foam board larger than the frame dimensions, and a sheet of board should be placed on the outermost object to shield it from light.

Only stable works on paper and related materials may be loaned, and they must be framed and remain sealed for the duration of the loan. The orientation of artwork should be determined by a conservator. Most works travel flat and face up. Those that travel upright in crates must be oriented with the hinged edge at the top to best support the weight of the object. Double-sided drawings do not have a solid backing, and thus to prevent sagging they must travel upright. The front and back glazing should be CUSHIONED with packing foam to limit vibrations. Protection from vibrations and from abrupt fluctuations in atmospheric conditions is essential to ensuring the safety of all works on paper during transport. The methods to be used are determined in consultation with the Registrar's Office and experienced packers.

Suggested Reading

Appelbaum, Barbara. *Guide to Environmental Protection of Collections*. Madison, Conn.: Sound View Press, 1991.

Kosek, Joanna M. *Conservation Mounting for Prints and Drawings: A Manual Based on Current Practice at the British Museum*. London: Archetype, 2004.

Northeast Document Conservation Center. *How to Do Your Own Matting and Hinging*. https://www.nedcc.org/free-resources/preservation-leaflets/7.-conservation-procedures/7.4-how-to-do-your-own-matting-and-hinging

Rayner, Judith, Joanna M. Kosek, and Birthe Christensen, eds. *Art on Paper: Mounting and Housing*. London: Archetype, 2005.

Smith, Merrily A., and Margaret R. Brown. *Matting and Hinging of Works of Art on Paper*. New York: Consultant Press, 1990.

13. PORTRAIT MINIATURES ON VELLUM, IVORY, AND METAL

Marjorie Shelley

Miniatures on ivory and vellum painted in watercolor and gouache are exceptionally fragile. These hygroscopic materials respond rapidly to extremes and fluctuations in RELATIVE HUMIDITY (RH) because of their thin structure and composite materials, each of which reacts to environmental change at a different rate. Generally no larger than a few inches in diameter and of shallow depth, these objects are composed of a vellum or ivory substrate, a water-based (or less often oil) paint layer, paper or vellum backings, locks of hair, tapes and adhesives, metal bezels, and frames made of gold, silver, metal alloys, papier-mâché or wood, glass, gemstones, and pearls.

ENVIRONMENTAL CONSIDERATIONS

Temperature and relative humidity (RH)

In order to accommodate the diverse requirements of these objects, environmental levels of 68–72°F (20–21°C) and 50–55%RH are recommended. High moisture levels can provoke warping in vellum and ivory, FUNGAL growth, and crystal formation on the paint layer, and accelerate blackening of lead white. Low RH levels and abrupt decreases in atmospheric moisture, which may occur during storage, transit, or display from the heat of gallery or VITRINE lighting, can cause ivory to split along the grain and vellum to distort, deformation that will cause weakly adhered areas of paint to separate from the support and flake off. Desiccation provokes CRAQUELURE and, in binding media and gum glazes, leaves a semi-powdery paint layer that is readily disrupted by any mechanical action, even as slight as an inadvertent brush of the fingertip. Miniatures painted in oil or enamel on metal pose conservation problems comparable to those for larger works on this type of support. To prevent paint loss and FLAKING, two of their most serious conservation problems, they must never be exposed to high temperature from any heat source, including spotlights. To avoid the development of ACIDITY and CORROSION of metal supports, stable temperature and RH conditions must be maintained at all times and locations.

Miniatures painted in gouache and watercolor, whether framed or encased, are particularly susceptible to mold. In an atmosphere of high humidity, microorganisms will flourish on the binding agents used in the paint layer: gums, sugar, and honey. However, miniatures in oil, also comprising many organic constituents in the paint and varnish layers, are not immune to attack. Mold appears most frequently as a pale gray bloom on the painted surface or the inner side of the glass. When on the paint layer, mold can pit the surface, and gray or colored fungal hyphae (which superficially look like cotton fibers) can cause irreversible damage if left untreated. Should there be a rapid drop in temperature, framed miniatures are vulnerable to condensation on the glass lens, a condition that can provoke staining, mold growth, and EFFLORESCENCE, a cloudy surface film on the paint. Chemically unstable cover glass, known as WEEPING GLASS, which is recognized by fissure formations or wet, waterlike droplets, also poses great risk of damage to the painted surface. They require the attention of a specialist conservator to open the miniature case and clean the glass, and may necessitate a MICROCLIMATE for display and storage.

Framing provides protection. In exceptional circumstances or for new framing, the miniature case may allow for the inclusion of a thin sheet of conditioned SILICA GEL to stabilize the internal conditions, but most of these objects leave no room to spare. Frequent examination of framed miniatures and careful control of the environment are the best safeguards against dangers common to these works. If problems are present or are suspected, the object should be brought to the immediate attention of a specialist conservator.

Light

Miniatures executed in watercolor or gouache, which invariably contain organic pigments and dyes applied in thin layers, especially in the flesh tones, are extremely sensitive to fading and thus must be exhibited under reduced LIGHTING conditions. If HALOGEN-tungsten lighting is used, ULTRAVIOLET (UV) and heat should be filtered, and light levels should be kept at 4 FOOT-CANDLES for exhibition and study; conditions that can be met with LED illumination. An automatic light system activated by a visitor's entry into a gallery is an effective means of limiting exposure. In other circumstances, such as storage or in transit, miniatures should be kept in darkness or protected with an opaque fabric or paper covering. The historic convex GLAZING of framed miniatures does not incorporate an ultraviolet filter, thus UV-filtering ACRYLIC SHEETING must be used for exhibition cases in which these objects are displayed. Display requirements must be determined on an individual basis. Their vulnerability to light is reason alone to limit exhibition periods to no more than three months every two years.

Air quality

Air quality must be maintained in areas where miniatures are displayed and stored. Even within their protective frames, lead white–containing pigments and silver paint are subject to blackening from atmospheric pollutants. Air filtration through an HVAC system to remove particulate matter is critical, and pollution SCAVENGERS may be recommended by the conservator if there is concern about neighboring materials that might off-gas and impair these objects. BUFFERS, such as silica gel, may be required in storage cases and vitrines to maintain desirable temperature and RH levels.

Fig. 15 Holding an ivory miniature between the fingertips

Because of the delicacy of both the painted surface and the support, an uncased miniature should be handled as little as possible and with extreme caution: even the warmth and slight perspiration of a hand can cause warping, and care must be taken not to touch the painted layer. To prevent cracking and splitting, miniatures on ivory must be held between the fingertips, lightly but firmly placing the thumb at the bottom and the index finger at the top **(Fig. 1)**. Pressure at the sides can cause ivory to split and vellum to bend and may provoke paint flaking. Cupping a miniature in the palm of the hand is dangerous and should always be avoided, as these materials are particularly sensitive to moisture, heat, and staining from skin oils.

Because of better tactile sensation, clean and dry hands are preferable to wearing GLOVES when handling uncased miniatures. For handling cased miniatures, NITRILE gloves, which do not snag, should always be worn to prevent skin oils from damaging frames, and to prevent staining or marring of the exposed surfaces.

When an uncased miniature needs to be moved or studied, it can be supported by sliding a small sheet of thin RAG BOARD with a beveled edge beneath. This will allow it to be transferred with minimal handling to a suitable tray or surface by holding the card, not the work of art. However, if the miniature is not planar, or it is rounded and warped, UNBUFFERED tissue paper that is crushed or folded should cushion it to hold it in place.

Except for specialist conservators, any other individuals handling framed miniatures should limit cleaning to the use of a soft, dry cloth. Metal polishes, soap and water, alcohol, or any other liquid should not be used, as they may damage the housing, and fluids easily seep into crevices in the casework, quickly compromising the painted surface and the support, as well as unexposed parts of the frame.

Unframing

Only an experienced expert should attempt to remove a portrait miniature from its sealed casework or refit one that has been unframed, as these are extremely complex objects. The mountings often have the intricacy of fine jewelry; the multiple components are very small, and their assembly is not straightforward. In addition to damage to the frame and glass, pressure on any of the parts can lead to splitting of the support and abrasion of the paint layer.

Glazing

Miniatures were traditionally covered with convex glass in order to protect them from moisture, dust, and dirt. Replacement glass should similarly be convex so it will rest only on the edges of the support, not on the painted surface. The air space provided by a convex glass cover also limits the likelihood of condensation should there be an abrupt drop in temperature. Miniatures should be sealed around the edge with goldbeater's skin or conservation-approved paper to protect from changes in atmospheric conditions and dust. Ordinary flat glass or acrylic sheeting should never be used for framing a miniature.

STORAGE

Fibrous materials such as COTTON BATTING should not be used to support or protect unframed miniatures because of the risk of fibers dislodging partially detached paint flakes, or snagging on small splits or tears in the support or projections in an intricate

frame. Miniatures should be supported on INERT, nonfibrous, soft, and lightly textured material, such as VOLARA® or other FOAM sheeting, or napped fabric such as ultrasuede or natural fiber velvet that will limit or prevent shifting of the object. Folded or crushed TISSUE paper should cushion and surround warped or convex objects that will not lay flat. Any material used in contact with these works of art must be ODDY-TESTED to ensure that it does not contain contaminants that will corrode the metallic elements or alter the pigments.

Framed and uncased miniatures should be stored horizontally in SOLANDER BOXES, acid-free ARCHIVAL boxes, or PLASTIC storage trays fitted with compartments that are PADDED with the above materials. Each compartment provides a separate area for an individual miniature, and for the various components (BACKINGS, cases, frames, etc.) of those that have been unframed. If compartments are not available and the miniatures are stored in file trays, locket hooks or paper identification tags attached to each object should be secured to the foam with nonrusting brass or stainless steel pins, or heat-shrunk polyethylene-wrapped pins. This housing, as well as storage for Solander boxes, should be in POWDER-COATED METAL cabinets. There should be sufficient space surrounding each object to permit lifting and safe removal. Drawers or trays holding miniatures should contain pollution scavengers or RH-buffering material to maintain the same atmospheric conditions recommended for display. For transit, framed miniatures should be loosely wrapped with ACID-FREE tissue for their preliminary packing and secured in place in the same type of container as recommended for storage.

Suggested Reading

Derbyshire, Alan. “Portrait Miniatures.” In *The National Trust Manual of Housekeeping: Care of Collections in Historic Houses Open to the Public*. Boston: Elsevier, 2006.

14. PHOTOGRAPHS AND DIGITAL PRINTS

Nora Kennedy

The term *photograph* comprises a wide range of materials and formats. Traditionally, a photograph consists of any image made on any surface with a light-sensitive medium. Once the image is exposed to light, it is "fixed" by some means, resulting in a monochrome or full-color image. In our contemporary world, analog imaging is being replaced with digital technologies. The digital file may be output onto a light-sensitive photographic material and processed in chemical solutions. Alternatively, the digital image can be printed in ink onto a variety of paper and plastic substrates. The media of this latter print type resembles a traditional photomechanical print, where a light-sensitive medium is not used in the final steps of print creation and the final print consists of inks made of dyes and/or pigments on a paper and/or plastic support. Most color and black-and-white photographs have a layered structure with paper, a plasticized paper, or a plastic sheet serving as the support or substrate. The image consists of dyes (color) or finely divided silver particles (black-and-white) held on the surface of the support in a thin layer of gelatin or other transparent binder. Other photographs, such as daguerreotypes and ferrotypes, may have a metal support, or, in the case of ambrotypes and glass plate negatives, a glass support. Many other image materials, binders, and supports can be used. When handling or caring for a photographic work or a digital print, all of its "component parts" must be considered.

ENVIRONMENTAL CONSIDERATIONS

Temperature and relative humidity (RH)

As with all works of art, maintaining proper environmental conditions is the best strategy for the long-term stability of photographic objects. Photographs are made of a myriad of different materials, all having their ideal temperature and RELATIVE HUMIDITY (RH) specifications. A level of 40%RH for storage areas is recommended for all types of photographic materials. For example, photographs on metal substrates ideally require a low RH for the best PRESERVATION. However, when they are housed in miniature cases made up of WOOD, textile, or leather and a metal clasp, the mix of materials requires establishing a compromise RH that will not adversely affect any component. When RH rises, the moisture-sensitive gelatin layer that holds the black-and-white or color image material on a paper or plastic support will begin to swell and may become tacky. At extremely high humidity conditions, this layer is very susceptible to the development of mold. For this reason, these photographs should be stored at a moderately dry RH level.

By the same token, for storage, lower temperatures maintained at consistent levels in the range of 30–60°F are recommended as long as RH levels can be kept at approximately 40% at that given temperature. If the relative humidity cannot be moderated, the photographs must be packaged at low RH with vapor-proof wrapping prior to placement in cold storage. Negatives on plastic supports and any color dye images are best preserved in a cold storage vault or in a cool environment. The lower the temperature, the greater the benefit achieved in image stability. However, the composition of the particular work should always be taken into consideration in determining storage temperatures. For example, the color dyes comprising the image in color photographs face-mounted to ACRYLIC SHEETING are best preserved in subzero

cold storage, but this temperature range, as well as the transit in and out of these conditions, may provoke deleterious effects on the photograph, ADHESIVE, and acrylic sheet composite.

Maintaining environmental standards within exhibition areas is extremely important, as light damage will be accelerated under adverse conditions. Because human comfort must be taken into consideration, temperature and relative humidity levels in photography galleries are maintained on average at 70°F and approximately 50%RH. Ideally, the lower temperatures and lower RH range should be favored.

Light

Photographs are generally exhibited under fairly low LIGHT levels and for limited periods of time, keeping total exposure to a minimum. The light levels and duration of display for any one image are determined on an individual basis, depending on the process type, light-sensitivity, and condition of the work, as well as the frequency with which it is requested for exhibition. Generally, light levels fall between 4 and 8 FOOT-CANDLES (40–80 lux). The frequency with which photographs are exhibited may vary from three months per year (for example, silver gelatin photographs) to three months every five years (for example, color photographs). It is important to remember that deterioration from light is cumulative and cannot be reversed.

For framed photographs, acrylic sheeting, such as PLEXIGLAS®, is generally preferred over GLASS due to its resistance to accidental breakage. Many types of GLAZING materials are now on the market, the choice of which to use being based on their ability to filter ULTRAVIOLET (UV) illumination and reduce reflections. The tungsten HALOGEN light used in museum galleries does not incorporate significant UV light; however, UV-filtering is essential for works on loan. The use of acrylic glazing with any photographs with friable media should be avoided.

Air quality

Another environmental factor critical to monitor is air quality. Of particular concern with silver images (salted paper prints, albumen prints, gelatin silver prints, daguerreotypes) is the presence of oxidizing gases. These are prevalent in drying oil-based paints, for example, which should never be applied to walls, floors, or exhibition cases in the proximity of photographs. Galleries and storage areas should be painted at least three weeks in advance of placing photographs in them and should be well ventilated to avoid damage from off-gassing of peroxides and VOLATILE ORGANIC solvents. Peroxides will cause rapid discoloration and fading of silver images particularly at high concentrations. This type of image deterioration is essentially irreversible. AIRBORNE PARTICULATE matter in the ambient environment should be kept to a minimum through filtration within the HVAC systems and through careful housekeeping within storage, exhibition, and work areas.

HANDLING

Clean hands or GLOVES should be used when handling a work of art, even if it is matted or framed. Cotton gloves should be clean and well-fitted. Disposable plastic LATEX or NITRILE gloves provide superior grip, suitable, for example, for handling glass negatives

and autochromes. A clean and uncluttered workspace, and one that is free of obstacles, should be prepared prior to examination or treatment of photographs.

The surface of a photograph should never be touched directly with the bare hand. This can cause permanent damage to both the silver image and the gelatin binder. The object should not be bent or flexed, as this may cause crescent creases. In plastic-based photographs, this type of damage cannot be reversed. All works of art should be housed to minimize damage through handling, as described below.

Fig. 1 [holding a matted photograph]. Image Credit: Taine Meller

When moving a matted photograph, it should be held at diagonally opposing corners providing the greatest support **(Fig. 1)**. If the matboard is thin and flexible, or if the photograph is not matted or mounted, one can carefully slide a sheet of RAG BOARD or other rigid material beneath the work for additional support. Matted photographs should have a slipsheet or INTERLEAF inserted between the window mat and mount to protect the surface of the photograph. When removing and replacing the interleaving sheet, it should be lifted with two hands, not dragged across the surface of the image, which can cause scratches.

Framed works should be moved in much the same way as unframed photographs, supporting them at diagonally opposite corners or midway along both edges. If the work seems too large or heavy for one individual, find help. Do not attempt to carry it alone!

Fig. 2 [replacing photo-corners] Image Credit: Taine Meller

When the VERSO of a photograph needs to be examined and is accessible, a sheet of paper can be slid beneath the primary support to gain access. One must never attempt to pry the photograph upward with fingers alone, as this practice will damage the edges. If the verso of the photograph needs to be examined but is not accessible, a photocopy of the reverse must be relied on (often found within the housing), or the digital image on the museum's computerized collections management database should be consulted. If the photograph has an important inscription on its reverse that must be made accessible, existing photo-corners or hinges can be cut by a photograph technician or conservator. One must never attempt to slide the object out of closed photo-corners and back in again, as this inevitably causes damage. For this reason, closed photo-corners should be replaced by a photo technician with ones that open **(Fig. 2)**. Before attempting to lift a matted photograph, the location of the hinges should be noted. Some may be hinged to the mat backboard along their left side. This practice has been supplanted by HINGING the photograph along the upper edge for superior weight distribution. Additional hinges are placed along the lower edge only if the photograph tends to curl upward and is "floated" in its window mat, allowing all four edges to be visible.

Any photograph that is not immediately returned to its storage box after viewing should be protected from light and mechanical damage by covering with a matboard or BLOTTER, and a three-dimensional sign should be placed above this clearly indicating that a work of art is beneath. Paper labels that identify the underlying photograph are also recommended, as they prevent unnecessary handling.

When working in the vicinity of a photograph, only graphite pencils may be used. Food and beverages are not allowed in areas where photographs are examined, stored,

or undergoing any type of conservation process. Dangling jewelry, neckties, and ID cards should be removed or secured so as to not damage these objects.

HOUSING AND STORAGE

Fig. 3 A window mat and mount makes an ideal housing. Image Credit: Taine Meller

Photographs ideally are housed individually within window mats and mounts, with a paper interleaf resting directly on the surface **(Fig. 3)**. Some photographs are housed loose within POLYESTER sleeves, supported with a thin, two-ply sheet of good-quality purified wood-pulp or rag matboard. Three-dimensional photographs may require four-flap folders or other custom-designed housings. All PAPER and PLASTIC housing materials used with photographs must pass the PHOTOGRAPHIC ACTIVITY TEST (P.A.T), an International Organization for Standardization, or ISO Standard (14523), that predicts possible detrimental interactions between the photographic materials and storage enclosures. Most conservation suppliers have this information readily available. In general, simpler materials are preferred to those that have complex ingredients, and papers and matboards with additives, such as BUFFERS, colorants, and ZEOLITES, must be used with caution. Note that if ideal environmental conditions are maintained, extensive deterioration will not be instigated by the housings.

Photographs in window mats and mounts are held in place with openable photo-corners or with hinges along the upper edge of the verso secured to a sheet of two-ply matboard. The two-ply sheet is taped or cornered to the mat backboard to enable easy removal of the hinged image to another mat, should a change for exhibition or storage purposes be needed. Photo-corners are preferred to hinges because they do not require that adhesive be applied directly on the photograph and are easily reversible. They do, however, require that the edges of the photographic mount or the image itself be covered or overmatted by the mat window to hide the photo-corners. When the image is to be “floated” within the mat opening, Japanese paper hinges adhered with WHEAT

STARCH PASTE are used. For overmatted works in particular, the inner edges of the mat bevel should be burnished to prevent marring or scratching the photograph. If an ERASER is used to remove measurement marks on a mat, all eraser crumbs must be brushed away in advance of hinging or cornering the photograph, as they can promote deterioration.

A light-weight, semi-transparent interleaving paper such as PHOTO-TEX® is used to protect the surface of the image within the window mat and mount. This slipsheet should be cut to slightly less than the mat dimensions so that it covers the entire work and does not slide leaving the photograph only partially covered. The interleaving should be clean and free of any folds or creases to avoid marring the surface of the photograph. GLASSINE and other interleaving materials should only be used for photographs in temporary or special circumstances.

Matted and sleeved photographs are housed in SOLANDER BOXES on shelves within climate-controlled storage areas. Solander boxes must be of the highest quality, but must air out for at least two weeks before they are put into use. They provide sturdy outer housing as well as some buffering from seasonal and daily environmental shifts. Matted works ideally should be stored with works of the same dimensions in a box made to accommodate them. When placing matted and sleeved works of different sizes within a Solander box, the largest matted work should be at the bottom, followed by housings of decreasing size. A matboard interleaf is inserted between mats of significantly different sizes to protect the exposed image area in the underlying larger work. Three-dimensional photographs such as albums, cased images, and large-format rolled photographs can be stored in custom-built housings.

Large framed photographs may be housed on storage racks or in vertical slots designed for this purpose. If they are stored without a covering, the lights in the storeroom should be off when personnel are not present to limit light exposure. If storage areas are used for study and extensive consultation purposes, all framed works should be covered to block light and protected from dust accumulation.

TRANSPORTATION WITHIN THE MUSEUM

Groups of matted or unmatted photographs should be transported in Solander boxes on carts with rubberized wheels, maintaining the same precautions to protect their surfaces as in storage. Small framed photographs may be stacked with a CARDBOARD or FOAMCORE interleaf to prevent scratching the underlying acrylic sheet or frame. They must always be placed face up to prevent hinged works from being pulled downward with gravity toward the glazing. Large framed photographs may be transported on side trucks, facing inward or outward, but with the frame and acrylic sheeting always protected with rigid cardboard or foamcore to avoid scratching and other damage (see Chapter 22 for a discussion of art in transit within the museum). Contemporary photographs are occasionally mounted directly to acrylic sheeting without frames, leaving their surfaces particularly vulnerable to abrasion and scratching. Special care should be taken with these works of art when transporting them within the museum.

Suggested Reading

Clark, Susie, and Franziska Frey. *Care of Photographs*. Amsterdam: European Commission on Preservation and Access, 2003. http://www.ica.org/sites/default/files/WG_2003_PAAG-care-of-photographs_EN.pdf

Jürgens, Martin C. *The Digital Print: Identification and Preservation*. Los Angeles: Getty Conservation Institute, 2009.

Lavédrine, Bertrand, Jean-Paul Gandolfo, and Sibylle Monod. *A Guide to the Preventive Conservation of Photograph Collections*. Los Angeles: Getty Conservation Institute, 2003.

Lavédrine, Bertrand, Jean-Paul Gandolfo, John McElhone, and Sibylle Monod. *Photographs of the Past: Process and Preservation*. Los Angeles: Getty Conservation Institute, 2009.

Pénichon, Sylvie. *Twentieth-Century Color Photographs: Identification and Care*. Los Angeles: Getty Conservation Institute, 2013.

Reilly, James M. *Care and Identification of 19th-Century Photographic Prints*. Rochester, N.Y.: Eastman Kodak Co., 1986.

Reilly, James M. *The Storage Guide for Color Photographic Materials: Caring for Slides, Negatives, and Movie Films*. Albany: State University of New York, 1998.

15. THE CARE AND HANDLING OF BOOKS

Mindell Dubansky

Three factors influence the condition of books: the environment in which they are stored, their binding structure and materials, and how they are handled. Each factor must be considered in the care of books to avoid causing irreversible damage.

ENVIRONMENTAL CONSIDERATIONS

The quality of the environment is the most important factor in the health of a book collection. To ensure that optimal conditions are met, a PRESERVATION assessment of the space provided for books should be carried out—whether this be a library, office, or historic room display. The purpose of a preservation assessment is to identify potential hazards to collections and identify preventative maintenance strategies. Issues to consider are building condition and environment, storage and handling procedures, and emergency preparedness (see Chapter 21). The ideal storage conditions for books are 60°F temperature and 55% RELATIVE HUMIDITY (RH). This may not always be possible to maintain, in which case environmental conditions should be as close to the ideal as possible, with fluctuations of temperature and humidity minimized.

It is important that temperature and humidity levels be maintained at all times, including nights, weekends, and periods when a library is not in use. Books should not be shelved on external walls, kept on the floor, or located in the path of ceiling or external water pipes and faucets, in proximity to radiators or other sources of heat, or near any source of dust or pollution. Fluctuations in atmospheric conditions generated by such circumstances or by unregulated equipment will advance deterioration, causing, for example, book materials to expand and contract, and provoking mold or desiccation.

LIGHT should also be controlled. Books in storage, like other ORGANIC materials, should be exposed only to the amount of light that is necessary for shelving and unshelving. Thus, electric lighting should be turned off when not in use, all DAYLIGHT avoided, window coverings drawn, and FLUORESCENT lighting filtered with ULTRAVIOLET (UV) sleeves.

HANDLING

Whereas works of art are rarely handled, books are distinctive in that they must withstand repeated handling and manipulation for use. Poor handling is a major cause of damage, and it is important that guidelines be followed by readers as well as staff responsible for their care.

Fundamental guidelines that must always be followed include washing and drying hands before handling books, preparing a clean reading surface, using only pencils (never pens) near books, and turning pages carefully. One must avoid placing any objects on opened or closed books, using a book as a writing surface, laying an open book face down, folding page corners, or turning pages with wet fingers.

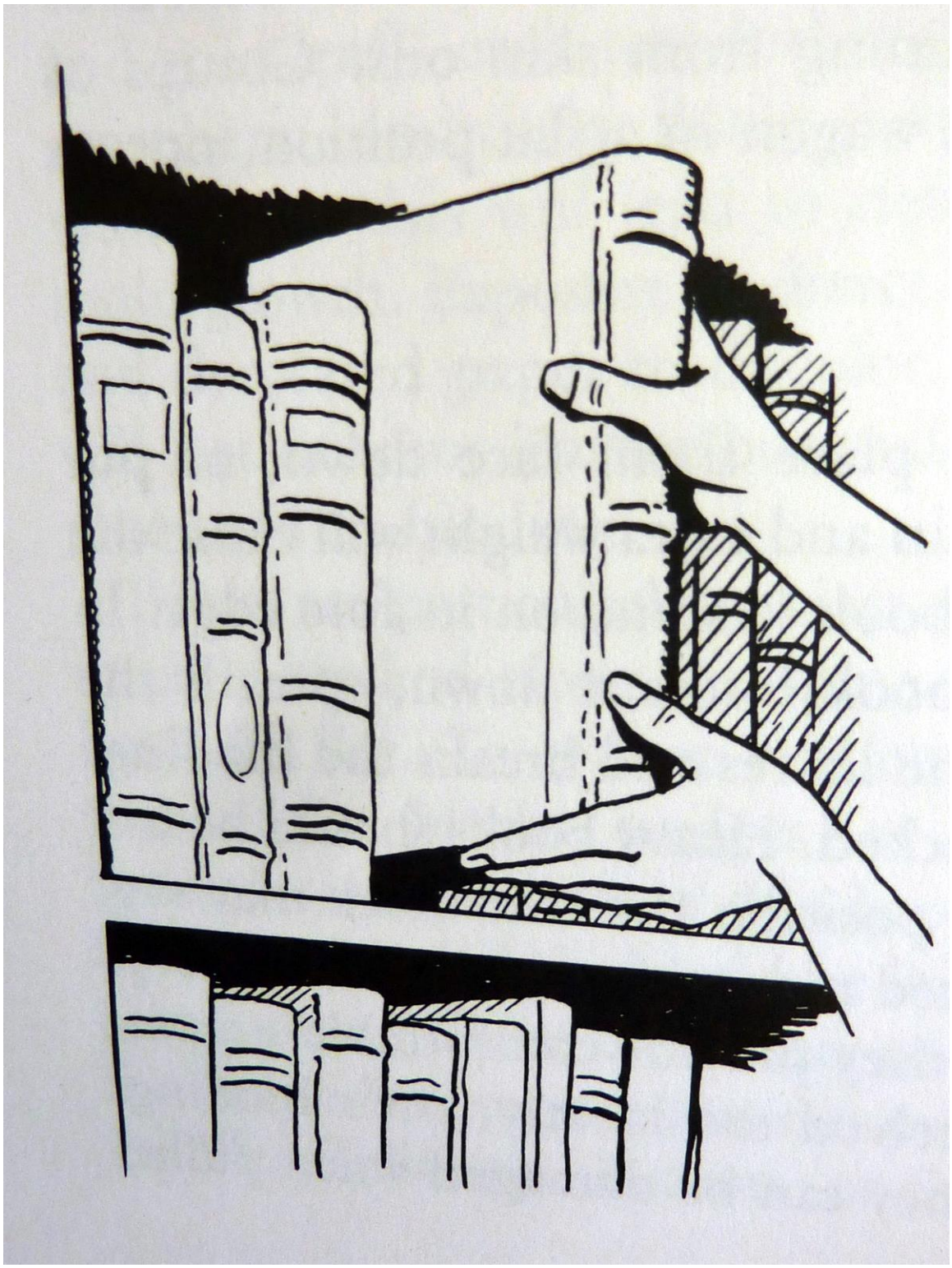

Fig. 1 A book is safely removed from the shelf by easing back the books on either side and grasping the volume, gently removing it, then readjusting the bookends.

To safely remove a book from a shelf, the books on either side should be eased back and the volume grasped, gently removing it, then readjusting the bookends **(Fig. 1)**. A book should never be pulled by its endband (the top rim of the spine), as this can

break the spine piece. To replace a book on a shelf, bookends must be loosened and existing books moved to create space, then the volume reinserted and the bookends readjusted. A large or heavy book must be supported with both hands, and a table or cart where the book can be placed kept nearby.

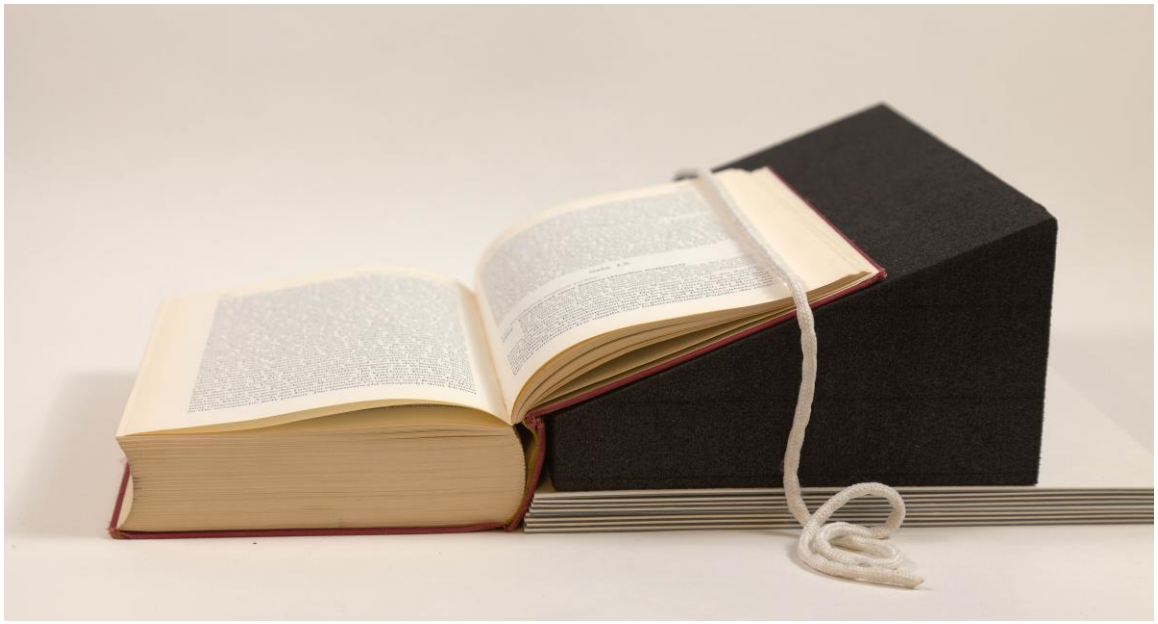

Fig. 2 A book in a book cradle

Books should never be forced open. In order to avoid unnecessary damage to fragile books, book supports or cradles should be used **(Fig. 2)**. Alternatively, blocks wrapped in nonabrasive material (such as felt or VOLARA®) can be used. Weights of various types may be necessary to place on the pages of an open book. These weights should not have any sharp edges that can damage the paper. For very fragile books, readers should be guided to facsimiles or digital copies, or library staff should assist the reader in handling. Books with foldout plates will require sufficient space for the extended pages.

Books that are opened for the first time are opened from the front cover, and each page is carefully turned and smoothed down until the end is reached; the same procedure is then carried out from the back of the book going to the front. Not doing so risks “cracking the spine”: permanently breaking the spine linings and adhesive.

Inclusions, such as paper clips, slips of paper, or adhesive-backed note paper, should not be used to designate pages and should be carefully removed when present. Inclusions cause physical and chemical damage, including irreversible staining, rust, tears, and distortion; nonetheless, they should be brought to the attention of the librarian or curator in case they are historically relevant to the writer or previous user of the book. Only thin, ACID-FREE paper should be used as a bookmark.

Very large books are difficult to handle. They are easily damaged during copying, therefore photography is recommended instead. Readers should seek instruction from a librarian or trained technician. Ideally, books should be copied on a “face up” copier or scanner, or photographed. If “face down” copiers are all that is available, special care must be exercised in not putting weight or stress on the spine. In addition to the condition of a book, the high light level generated by copying machines makes this procedure inappropriate for rare books.

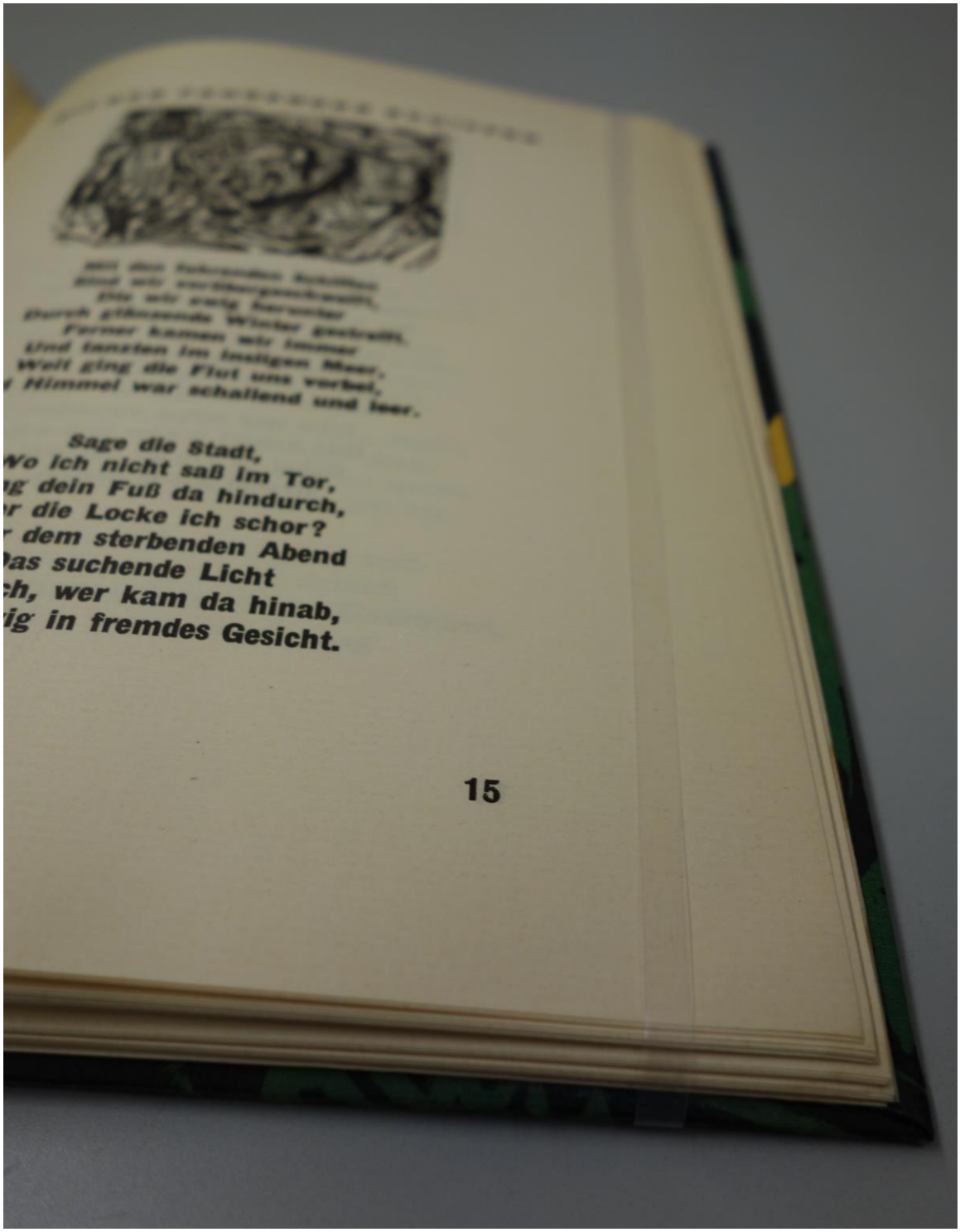

Fig. 3 Pages of open books are held back with polyester or polyethylene straps. The most fundamental phase of strapping entails placing acid-free paper or thin rag board between the outside of the book cover and the ends of the MYLAR® strap, and securing the latter with archival tape. The paper insert will prevent the archival tape from coming in contact with the book cover.

The same environmental and handling guidelines noted above should be followed when preparing books for exhibition. Leather bindings, colored plates, and papers of all types are highly vulnerable to light damage, thus light levels should not exceed 5–8 FOOT-CANDLES, UV must be excluded by the use of filters, and exhibition time limited to three months per calendar year. It is important that all phases of supporting a book for exhibition be carried out by a conservator or trained technician to avoid irreversible damage from mishandling. Custom-made book cradles or FOAM or RAG BOARD blocks, sometimes inclined at a slight angle toward the viewer, are used to support these objects. The design of a book support is based on the type, condition, weight, and dimensions of the book and of the exhibition case. Pages of open books are constrained with a POLYETHYLENE tape loop attached with a small piece of double-sided TAPE (STRAPPING) **(Fig. 3)**.

STORAGE

High-quality shelving will extend the life of a collection. Smooth, baked POWDER–COATED, enamel-finish metal shelves are recommended for books. Most WOODS and COMPOSITE WOODS, such as plywood and particle board, will produce damaging ACIDIC byproducts. If wood is the only shelving option, it should be lined with POLYESTER film or ACID-FREE PAPER. In order to keep books dry in case of flood, the lowest shelf in a bookcase should be at least 4 inches off the floor; top shelves should have a lip to deflect water and dust and to limit light. If there is concern about any of these issues and the books cannot be removed to another location, polyethylene sheeting may be placed over the top of the bookcase as a temporary protective measure.

The materials and dimensions of a book must be considered when determining how it is to be shelved. Large books should be shelved flat. A book too tall for a shelf can be shelved spine down if it is supported at the sides. Shelving too loosely or too tightly can cause damage. Shelves should be about 60% full and books should be supported with sturdy bookends. Brittle leather, fragile paper, and books with protruding parts generally benefit by a well-fitting ARCHIVAL box, dust jacket, or other enclosure for their protection and to prevent damage to adjacent books. Paper-based enclosures should be BUFFERED and have a low lignin content. Blueprints and photographs should be stored in UNBUFFERED paper enclosures. For archival PLASTIC enclosures, clear polyester film, polyethylene, and POLYPROPYLENE materials are recommended; polyvinyl chloride and CELLULOSE ACETATE are not safe.

TRANSPORT

Book trucks are used for transport within a library, and should be easily maneuverable and stable. Vibrations should be avoided, thus care must be taken when traversing door and elevator openings, or traveling on uneven footing. The route should be preplanned and pedestrians warned of trucks in the area. When moving long distances, the truck should be equipped with guardrails. The truck should not become top heavy, and books should not protrude beyond its perimeters. Books should be placed upright and bookends used to keep them from falling. Large books should lay flat. Irregularly shaped books, such as albums and ledgers, should not be stacked.

Books to be packed for transport should be wrapped individually. Several wrapping layers are used, the first being smooth, acid-free paper closed with archival tape. For soft bindings, two wrapping layers are used. Acid-free boards, cut to the size of

the volume, are placed on the outside of the front and back covers. The second wrapper should be a PADDING material (such as BUBBLE WRAP) that will absorb shock and, with the presence of the first layer of acid-free paper, buffer changes in relative humidity and temperature. Once wrapped, the book is placed in a strong carton-containing CUSHIONING MATERIAL. The number of volumes placed in one carton is determined by weight, size, and value, but should not exceed 20 pounds.

Suggested Resources

Northeast Document Conservation Center
https:www.nedcc.org

Conservation Center for Art and Historic Artifacts
http: www.ccaha.org/publications

Library of Congress
http://www.loc.gov/preservation/care/books.html

16. EAST ASIAN PAINTINGS ON SILK AND PAPER: HANGING SCROLLS, HANDSCROLLS, FOLDING SCREENS, STORAGE BOXES, ALBUMS, AND FANS

Jennifer Perry

East Asian paintings are those in which a brush is used to apply carbon-black ink and mineral and organic pigments mixed with animal glue to a substrate of paper or silk. Typical painting formats include hanging scrolls, handscrolls, folding screens, sliding panels, and album leaves. These paintings react readily to changes in environment. Their complex laminate structures, adhered with WHEAT STARCH PASTE, are susceptible to eventual separation of layers, and lifting and FLAKING of painted surfaces. The mechanical action of rolling and unrolling hanging scrolls and handscrolls, and the opening and closing of folding screens, leads to wear and tear in both the mounting and the painting. Their surfaces are vulnerable to deterioration from exposure to LIGHT, atmospheric pollutants, changes in RELATIVE HUMIDITY (RH) and temperature, and contact with poor-quality materials while in storage or on display.

ENVIRONMENTAL CONSIDERATIONS

East Asian paintings are subject to physical, chemical, and biological damage. Unlike Western works of art, most of these objects were intended for temporary display. Reduced lighting, optimal temperature and humidity, and clean air will extend their life. An inadequate environment and neglectful handling will result in deterioration. Being composites of INORGANIC and ORGANIC materials, these objects should be displayed and stored in controlled conditions of 68–72°F temperature and 50–55% relative humidity. Dryness and high temperature cause deformation and embrittlement; moisture will encourage delamination and distortion of the multiple layers, mold, and FOXING. As a BUFFER against climate changes, these objects should be protected in their original wrappers and boxes, or ACID-FREE materials, and kept in closed cabinets. For objects requiring specific RH conditions, MICROCLIMATES may be necessary. Regular housekeeping is essential, and air quality should be monitored to eliminate particulate matter, AIRBORNE pollutants, and off-gassing from ACIDIC storage and display materials. To guard against embrittlement of the substrates and fading of pigments, dyes, paper, textiles, and wood, lighting should not exceed 5–8 FOOT-CANDLES and must be ULTRAVIOLET-filtered, and objects should be rotated on a regular basis.

THE MOUNTING STRUCTURE

The various materials that constitute each of these formats are collectively referred to as the mounting structure. The skills brought to the mounting and its components, and how they have been maintained, are critical to their condition. The style and elements of the mounting provide both the means of stabilizing the object and an aesthetic environment for its appreciation. While many parts of a mounting are not visible on the exterior, each of the components and their arrangement has a relation to the whole. Even when the work of art and mounting appear sound, the state of preservation of the underlying structure must be understood before attempting to handle, move, or open it, thus the guidance of a conservator is essential. These formats are readily damaged by

mishandling. Skill in safe methods of opening, rolling, and unrolling are essential for their PRESERVATION.

HANDLING BASICS

- Jewelry, watches, and ID badges should be removed before handling these objects.
- Hands should be washed and thoroughly dried before and at intervals during handling.
- A clean, flat preparation area should be created for hanging and viewing scrolls.
- Only one work of art should be handled at a time.
- The surface of any painting should never be touched.
- Clean, smooth WEIGHTS should be used for display and viewing, but placing them on image areas should be avoided whenever possible.
- Snug-fitting nitrile GLOVES should be worn when handling objects with metal or lacquer attachments. Cotton gloves, which may snag, are not recommended.
- Only graphite pencils should be used in the vicinity of these artworks.

HANGING SCROLLS: UNROLLING AND RE-ROLLING

Fig. 1 Start with hanging scrolls. Precise handling techniques will prolong the life of scrolls. Before handling scrolls, wash and dry your hands thoroughly. Gloves are not recommended as they tend to catch. If they are worn, they should fit snugly. Before hanging a scroll, assess its stability. Check weight-bearing points including the hanging and rolling rods, cords, hanging hardware, and knobs. If the scroll is rolled on a futomaki, or wide diameter roller, be sure to re-roll the scroll with it in the proper orientation.

Before hanging a scroll, its stability must be assessed. Weight-bearing elements, including the hanging and rolling rods, cords, hanging hardware, and knobs, should be checked **(Fig. 1)**. A wall hook should be prepared before picking up the scroll. Oversize scrolls should hang from two hooks to prevent the hanging rod from bending and to keep the mounting in plane. Scrolls over two feet wide should hang on multiple hooks, with two people assisting in the process. For scrolls that are boxed, scroll knobs and hanging cords, if stable, can be used to lift the object. Once clear of the box, the scroll can be cradled from underneath in one hand, while unwrapping the cord with the other hand. For very large scrolls, one end can be rested on a table. Hanging strips on Japanese scrolls (J. *futai*) should be unfolded before transferring to the wall.

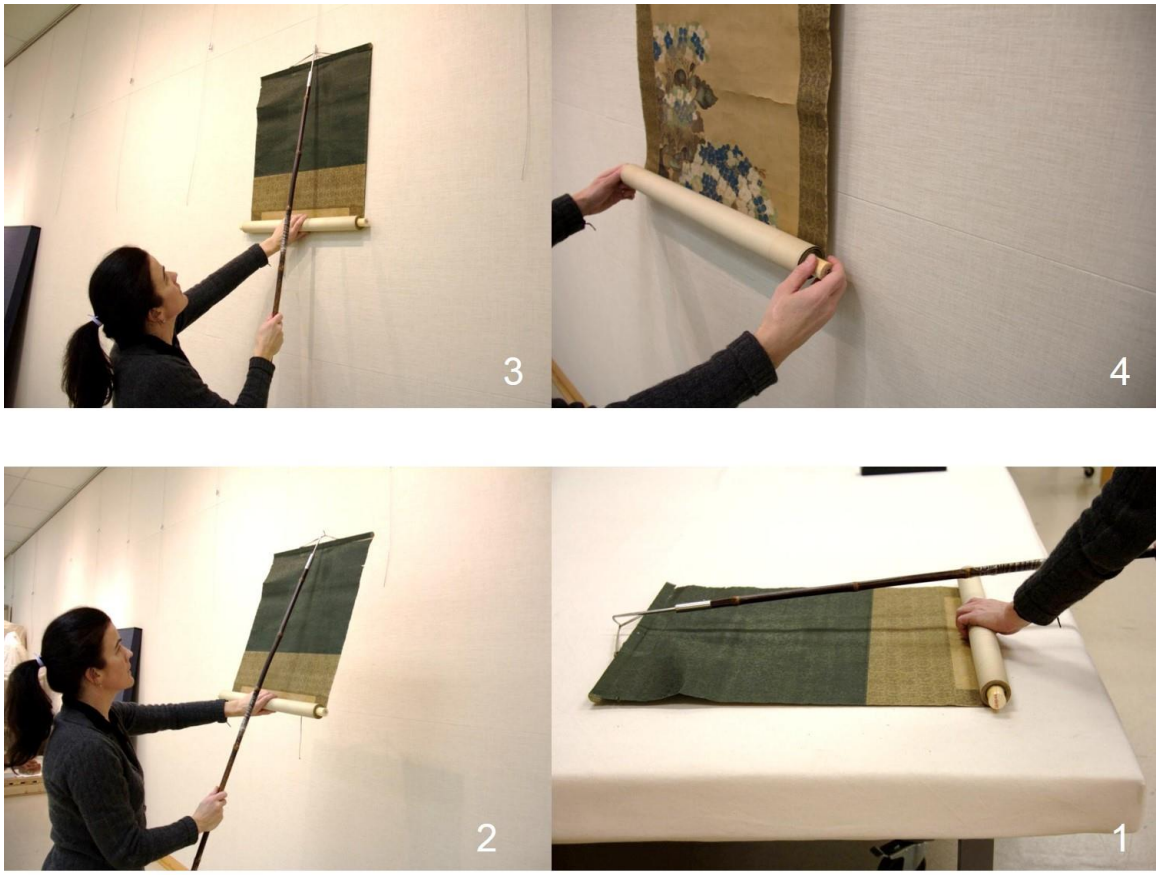

Fig. 2 If the wall hook is at a comfortable height, cradle the rolled scroll in one hand and grasp the center of the hanging cord with the other. If the wall hook is too high, use a hanging pole with hook, or yahazu, and use this to hook the hanging cord (will show later). Maintain tension between the rolled scroll and hanging cord while you transfer it to the wall hook. DO NOT HANG SCROLLS ON THE WALL OR REMOVE SCROLLS FROM THE WALL WHILE THEY ARE FULLY UNROLLED! Once the hanging cord is placed securely on the hook, let go of the hanging cord, or remove the hanging pole, and shift the free hand to the outside edge of the scroll. Slide the supporting hand to the opposite end of the scroll. Gently grasp the knobs and outer edges of the scroll in either hand and slowly unroll the scroll. DO NOT UNROLL WHILE HOLDING THE CENTER OF THE SCROLL; THIS RESULTS IN CREASING OF THE SCROLL AND PAINTING.

The scroll should be unrolled on a clean, flat surface, until the top portion of the mounting is visible. The wrapping cord can slide to one side of the hanging cord. If the wall hook is at a comfortable height, the rolled scroll should be cradled in the palm of one hand and the center of the hanging cord grasped with the other. If the wall hook is too high, a hanging pole with a hook (J. *yahazu*; C. *hua cha*) can be used to transfer the

hanging cord, all the while maintaining tension between the rolled scroll and hanging cord. Once the cord is placed securely on the hook, it can be released, or the pole removed, and the free hand shifted to the outside edge of the scroll. The supporting hand should slide to the opposite end of the scroll. The knobs and outer edges of the scroll can be gently grasped in either hand and the scroll slowly unrolled **(Fig. 2)**.

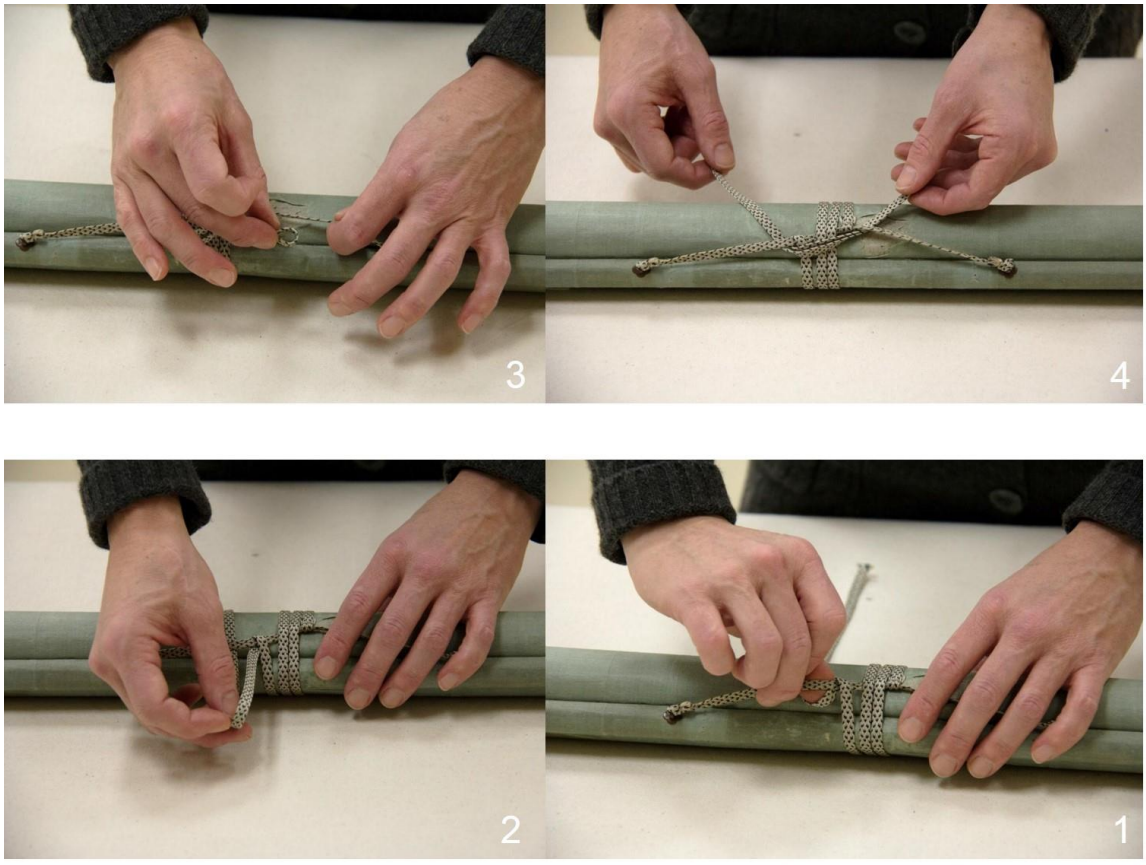

Fig. 3 Roll up the scroll and re-tie the wrapping cord. Do not tighten the scroll or wrap the cord too tightly

For re-rolling, the ends of the bottom roller should be grasped and rolled slowly and evenly, stopping as necessary to correct tension and telescoping. If the scroll is on a wide-diameter roller (J. *futomaki*), the *futomaki* must be placed in the correct orientation over the roller bar before re-rolling. When the scroll is rolled to the height of the upper mounting border, or the ends of the *futai*, the scroll should be cradled with one hand and the hanging cord lifted from the wall hook with the other. If using the hanging pole, tension should be maintained with one hand while inserting it, then the scroll removed from the hook. While carrying the scroll, tension should be maintained between the rolled scroll and the hanging cord. The scroll should then be placed on the table, the *futai* (if present) refolded, the rolling up completed, and the wrapping cord retied. The wrapping cord should be wound around the scroll toward oneself, without tension, tightening the scroll, or wrapping the cord too tightly **(Fig. 3)**. To protect the outer layer of the scroll, a strip of medium-weight Asian paper may be used to encircle the scroll at the center before securing with the cord. A closed or rolled scroll should never be squeezed, but cradled with a cupped hand.

The scroll should be wrapped in its cloth wrapper and replaced in its box. The interior of boxes for Japanese hanging scrolls often have U-shaped wood supports at

each end, the larger of which is intended for the top roller. These pieces support the roller knobs and prevent the weight of the scroll from resting on the bottom of the box.

HANDSCROLLS

To remove a handscroll from its box when there is no lifting mechanism, the box should be tilted and the scroll allowed to roll into the palm of the hand. Handscrolls are best opened and displayed on flat surfaces; however, they may be installed safely on a deck at angles up to 30 degrees.

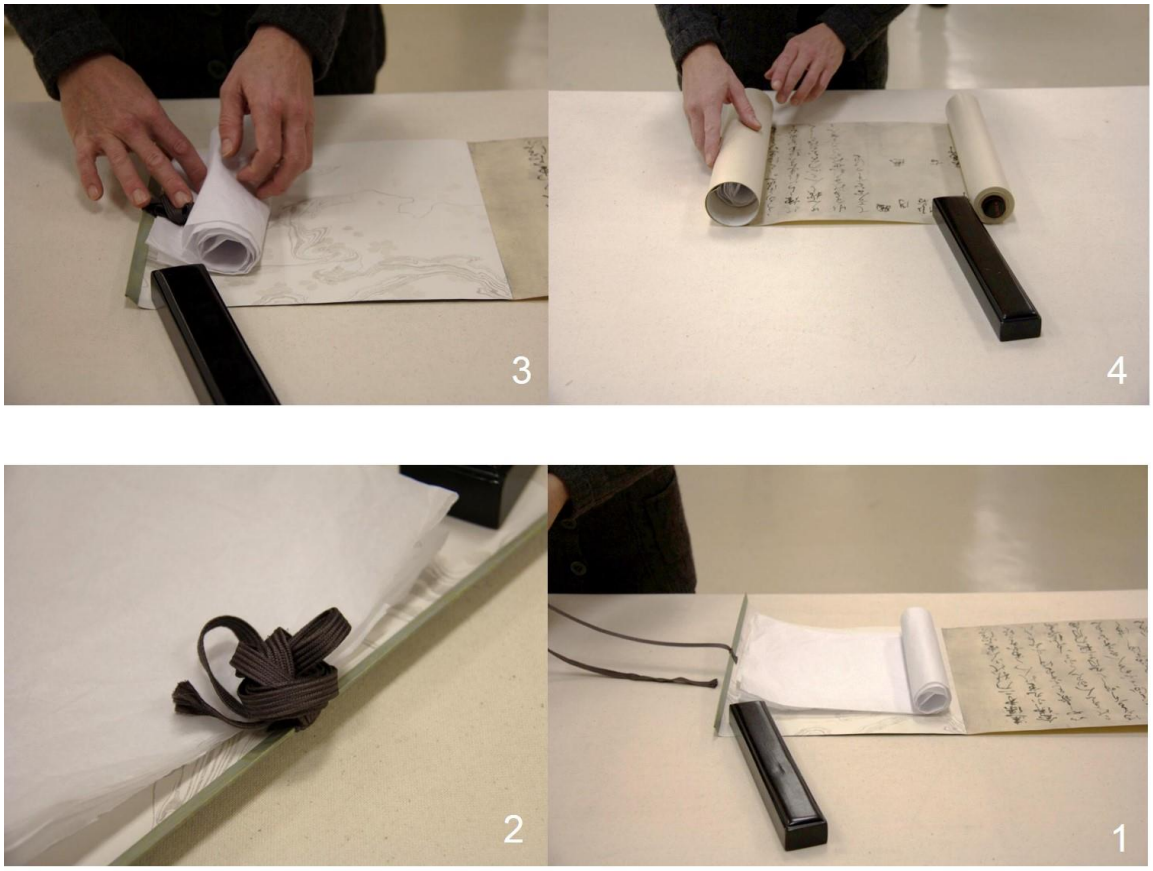

Fig. 4 Gently tie up the cord and roll into a sheet of tissue to prevent it from falling out during rolling. This is especially important when heavy jade or ivory toggles are present. The tissue will help support the front end of the scroll when it is rolled and prevents damage. Unroll the scroll a section at a time and use weights along the top and bottom edges. Do not place weights on image areas, if possible. Do not drag the scroll across the table top, lift and move with both hands. Gently correct when telescoping occurs.

When opening, the cord and clasp should be secured in a small roll of tissue or a 2–3 inch diameter tube to prevent them from falling out during unrolling, and to help support the front end of the scroll when it is closed. The scroll should be unrolled on a table one section at a time, stabilizing it by carefully placing bars of glass, ceramic, or wood on its surface along the top and bottom edges and avoiding image areas **(Fig. 4)**. The scroll should never be dragged across the table; instead, it should be lifted and shifted with both hands.

Fig. 5 On the left, where the rolled scroll is solid with no opening, a ribbon can be placed diagonally across the end from the left bottom to the top right. On an angled deck, a small PLEXIGLAS® support or POLYETHYLENE-covered pins may be used to secure the left section of the scroll.

To secure a handscroll for exhibition, a ribbon may be passed through its open right side, anchoring the ends to the deck with pins, above and below the scroll. On the left, where the rolled scroll is solid with no opening, a ribbon can be placed diagonally across the end from the left bottom to the top right **(Fig. 5)**. On an angled deck, a small PLEXIGLAS® support or POLYETHYLENE-covered pins may be used to secure the left section of the scroll.

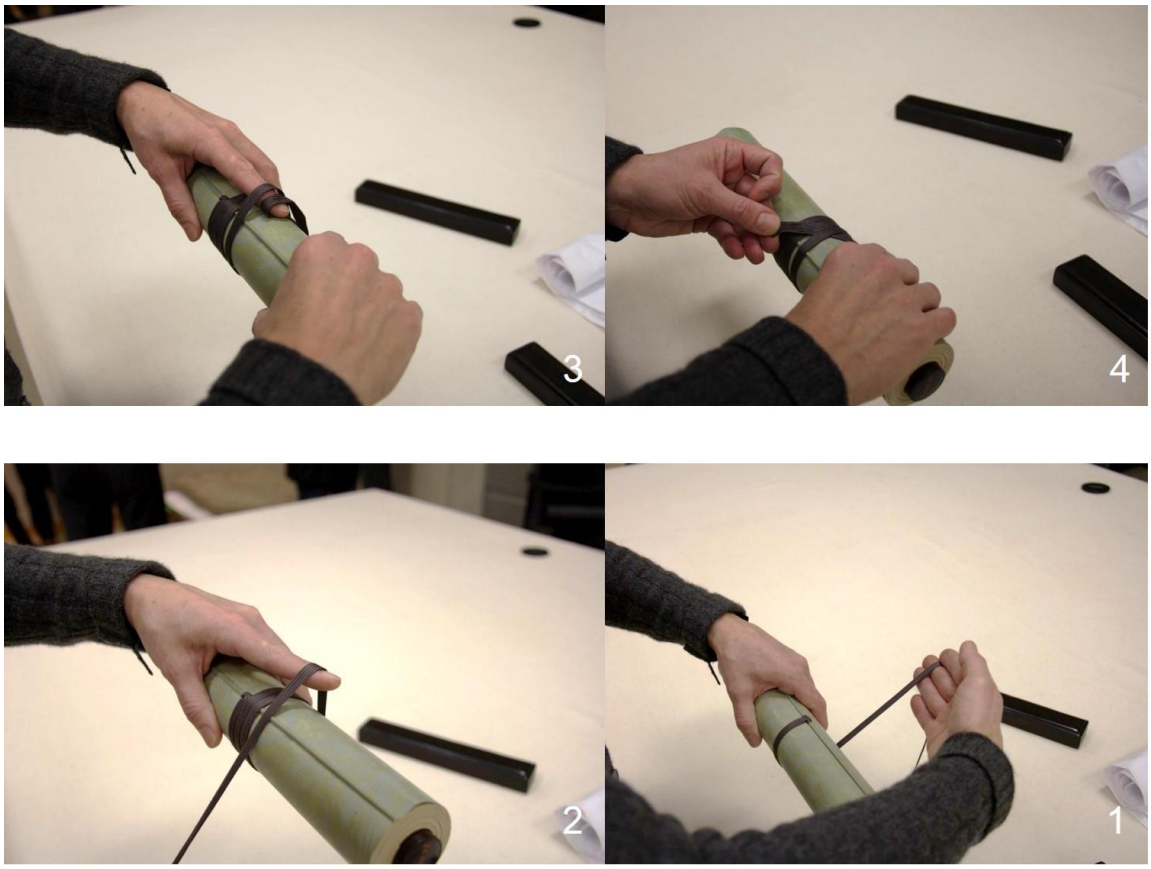

Fig. 6 When re-rolling, gently tighten the slack and correct telescoping. Use light tension when winding the cord. Do not tie too tightly.19

Handscrolls should be re-rolled slowly, with uniform tension **(Fig. 6)**. As the scroll is rolled closed, slack should be gently tightened and telescoping corrected by placing the hands at the top and bottom of the roll and pressing gently to realign the edges. The scroll should never be forced into alignment by excessive pressure; this can soil and permanently crease the edges, which are critical to protecting the work of art. Light tension should be used when winding and tying the cord, winding toward oneself and in the direction of the rolled scroll. When the closed scroll is held, the roll should be cupped in the hand, never squeezed. The scroll should be placed in its wrapper before returning to its storage box.

STORAGE BOXES AND WRAPPERS

A storage box is of integral importance to the object it contains. Since ancient times, scholars, tea masters, priests, and collectors inscribed boxes with brush and ink, naming the object or commenting on its history. Such notations may aesthetically enhance the object and often indicate provenance. Traditionally, scrolls have been stored in well-crafted wooden boxes with tight-fitting lids: low-resin paulownia wood is common in Japan; various hardwood boxes or a textile wrapper in China. Contemporary Chinese boxes are often cloth-covered paperboard with a padded interior.

Storage boxes are also of great importance to the object's preservation. They act as dust and light barriers, limit direct handling, and serve as microclimates moderating fluctuations in temperature and relative humidity. For scrolls without boxes, substitutes

may be made of ARCHIVAL, acid-free corrugated board. When the original wrapper is absent, prewashed cotton MUSLIN, soft TYVEK®, or ACID-FREE PAPER can be used.

Scroll boxes should not be carried by their tying cord, but cradled from underneath. Gummed and pressure-sensitive TAPE, glue labels, and any pointed writing instruments should not be used for labeling: each will permanently mar these surfaces. Small, prewritten paper labels are safe but must be applied by a conservator using only reversible ADHESIVES.

When loaning scrolls, the suitability of the storage box should be assessed for travel. If necessary, a temporary replacement box made of acid-free board can be provided, allowing space for wrapping the scroll. The box is then CUSHIONED in another container for shipping. When a box is included in the loan, the box as well as the wrapper, interior *futomaki*, or historical papers must be documented and condition-checked.

FOLDING SCREENS

Folding screens are generally even-numbered, with up to twelve panels, and often exist in pairs. The construction of a folding screen begins with a latticework interior panel, traditionally made from light, nonresinous wood. As many as ten layers of paper of various types and thicknesses are applied to each side of the panel framework, and each unit is joined by paper hinges. Following preparation, paintings or calligraphy on silk or paper are adhered to one side of the panels; the reverse sides of the panels are mounted with decorative papers or textiles. Lastly, an exterior wood or lacquered frame is attached to the outer edges and fitted with hardware at the outer corners and often along the left and right sides. Hardware fittings are primarily decorative; however, they serve to protect the exterior frame corners when the screen stands or is open. Fittings are made as sets and a piece lost is irreplaceable, thus condition reports should indicate the presence or absence of these elements. The type of wood, its cut, seasoning, and the manner in which the latticework is joined are critical to the longevity and stability of folding screens. Improper materials and craftsmanship can lead to torque, as well as splits in the paper layers and the work of art; such damages are worsened by extremes and fluctuations in environmental conditions.

Handling folding screens

Nitrile GLOVES are recommended for handling screens, as they provide a firm grip and prevent skin oils from damaging lacquered frames. One must be alert to the hollow screen structure that makes these panels vulnerable to puncturing. *Screens should be closed when moving to avoid stress on the hinges.* When lifting, one hand is placed at the middle of the folded edge and one at the middle of the frame edge without compressing the panels, but holding them as if pressing the palms of the hands together. A closed screen should not be left unsupported, as it will fall over.

Fig. 7 To open a six-panel screen, the screen should be placed in the center of a flat, even surface with the front hinges facing the handler. The screen is handled along the top or outer edges of the lacquered wood frame, surrounding silk borders at the outermost edges, and the back hinges, not along the front folds, as this will damage the painting. The screen should be opened at the middle fold 90 degrees while rocking the screen slightly backwards. Working from the center out and following this procedure, the screen should be unfolded one section at a time while holding the top corners of the frame to support the hinges. Once open, slight adjustments can be made to position the panels. To close a folding screen, the procedure should be reversed.

To open a six-panel screen, the screen should be placed in the center of a flat, even surface with the front hinges facing the handler. The screen is handled along the top or outer edges of the lacquered wood frame, surrounding silk borders at the outermost edges, and the back hinges, not along the front folds, as this will damage the painting. The screen should be opened at the middle fold 90 degrees while rocking the screen slightly backwards. Working from the center out and following this procedure, the screen should be unfolded one section at a time while holding the top corners of the frame to support the hinges. Once open, slight adjustments can be made to position the panels. To close a folding screen, the procedure should be reversed **(Fig. 7)**.

In storage, screens are kept folded in cloth bags with cotton STRAPPING for support and for handles. In the Metropolitan Museum, they are stored upright on a sliding panel system that separates and secures them. For exhibition, folding screens are customarily displayed on a deck with panels at angles, allowing the screen to stand safely without support. A BARRIER or enclosed case is required to prevent them from being touched by visitors.

ALBUMS AND FANS

Illustrated and printed albums and books have complex structures. They consist of layers of paper, adhesive, and sometimes heavy covers of card, wood, or lacquered wood with leaves joined by various methods. Because these materials may be abraded and torn at the joins and folds from decades of wear and use, it is important to note areas of weakness and broken hinges or splits before undertaking any handling procedure. To prevent tearing, torque, or damage to any section, care must be taken not to stress the object's natural alignment. The hinges—the binding mechanisms of these works—are structural elements that respond to movement when handled.

East Asian albums generally open along the left side or bottom edge. When opening, only one page should be turned at a time, supporting the outer edge of the page with one hand and the hinge with the other. Cradles or WEDGES should be used to support them in an open position for study or display. For display, pages are held in place with straps made of polyethylene or JAPANESE PAPER.

For storage, the original orientation of the object in its box or wrapper should be maintained. The title slip is usually affixed to the album or book at the upper right edge of the cover or box. Often books and albums have their own cloth protective wrapper that also serves to keep a multivolume set together, cushions the book, and aids in safe removal and replacement in the storage box. Storage boxes, which sometimes have two or four flaps, may be made of wood, lacquered wood, or cloth-covered paperboard. If a new box is required, it can be made of acid-free corrugated board. Unlike Western books, East Asian albums and books that are not boxed should be stored flat when possible. When stored vertically, their weight may cause distortion, joins to break, and edges to bend. These objects should be stored and transported flat.

Folding fans and flat fans with handles are composites of paper, silk, wood, ivory, lacquer, and bamboo, with fasteners that may also include metal. They must be inspected before any handling procedure. They are invariably fragile because of their structure and weakened moving parts, and repeated opening and closing will cause wear, loss of pigment, or other damage. No attempt should be made to open or close them without the guidance of a knowledgeable person. Their display position depends upon their condition. East Asian folding fans may be stored in a closed position in their cloth bags or in cloth-wrapped boxes, or stored open in PADDED, acid-free boxes. Flat fans may be stored in acid-free CARDBOARD containers, or in acid-free RAG BOARD mats.

TRANSPORT WITHIN THE MUSEUM

Most screens and scrolls can be lifted and moved safely for short distances by one person. If two people are not available to hand-carry an object, a side truck will be necessary. A screen should be completely closed when it is moved. When using a side truck, the screen should be placed upright or slightly angled, and secured in position. If the truck padding is insufficient, loosely crumpled tissue, small covered pillows, or other flexible, soft material should be placed between the screen and the tie or straps holding it to the cart or to any hard surface it might touch.

Hanging scrolls, handscrolls, albums, and fans should be transported within the museum in their boxes or mats, and on carts *in a horizontal position*. Unboxed objects should be cushioned to prevent vibrations and movement while in transit.

Suggested Reading

Hare, Andrew. “Guidelines for the Care of East Asian Paintings: Display, Storage and Handling.” *The Paper Conservator* 30, no. 1 (2006), pp. 73–92.

Wills, Paul. “Far Eastern Pictorial Art: Form and Function.” *The Paper Conservator* 9, no. 1 (1985), pp. 5–12.

17. THE CARE AND HANDLING OF FLAT TEXTILES

Florica Zaharia

The Metropolitan Museum's textile collection is one of the most comprehensive in the world. Within this collection, the category of objects designated as flat textiles encompasses great variety in type, time period, place of origin, and size. The range, which spans 5,000 years, includes archaeological textiles, tapestries, carpets, quilts, ecclesiastical vestments, embroideries, laces, and modern synthetics. Also included are lengths and fragments of luxurious fabric made to be enjoyed, or meant as a tool for communicating messages among great rulers and religious figures around the world. Their size varies from fragments one inch square to tapestries and carpets that are hundreds of feet square; and their condition from the badly compromised by age and use to ones in excellent condition.

Because of this diversity, a basic understanding of textile materials—their physical and chemical characteristics and their condition—is essential for their care and handling. The most fundamental issue for historic textiles is that the threads from which they are woven are of varied types and strengths, made from natural fibers dyed with a vast range of hues. Both the specific morphology and chemical composition of natural fibers are critical to their PRESERVATION, as each type will react differently to environmental conditions. Almost all are sensitive to LIGHT. Additionally, fibers from around a plant's seed, or from the stem, the bark, or the leaf, are predominantly CELLULOSIC in composition and are especially sensitive to ACIDS. Fibers from animals, which can be external short fibers such as wool, hair, and fur, or secreted filaments such as silk, from the silkworm, are composed of PROTEINS, and are sensitive to alkalis, insects, and fungi. Among these fibers, silk is the most sensitive and readily damaged. Minerals, such as gold, silver, and copper, which compose the metal threads that were used for the most expensive textiles, are often subject to CORROSION, and SYNTHETIC fibers and dyes in modern textiles are similarly varied in type and reactivity to unstable environments.

Most textiles have a woven structure, in which a set of stronger threads, called the warp, run parallel to each other throughout the length of the textile. Another set of threads, called the weft, are inserted between the warp threads and run perpendicular to them in a specific preset order. The weft can be continuous from one selvage to another, or it might be discontinuous, stopping short of the selvages in following a specific pattern. There are exceptions to the general rule of perpendicularity of the weft to the warp, as for example the nonhorizontal weave that often occurs in tapestry. Around the world, and throughout history, different cultures and regions have produced numerous weaving structures, from the simple plain weave in which the weft passes successively over and then under one warp, to the complexly woven velvets in which a supplementary warp is used for the pile that fully or partially covers the ground weave. Also, not all textiles are woven. Felt and lace are among the most commonly encountered NONWOVEN textiles.

The condition of a textile is determined by a complex set of factors that work in relation to one another. These factors include the type of fibers and the specific process used in their manufacture, the thickness and type of thread, the dyes, the textile's structure and texture, and its history or age and use. What may appear to be a textile in good condition might in fact be an extremely fragile one that needs special care. Because textiles are predominantly ORGANIC in composition, they are subject to degradation through aging. However, the various oxidation processes that provoke

degradation can be significantly controlled by maintaining proper environmental conditions, adhering to established handling procedures, and providing appropriate facilities for display, storage, and treatment. It is essential that any staff who handles textiles be aware of the standards for preservation described below, be able to identify condition and housing problems, and know when to contact a museum expert who can address the situation.

ENVIRONMENTAL CONSIDERATIONS

One of the most important factors in preserving a museum's textile collection is maintaining optimal environmental conditions, that is, controlling light, relative humidity, temperature, air quality, dust, and pollution.

Light

All kinds of light are harmful to textiles, as they will provoke irreversible and cumulative photochemical degradation. The most visible effect of light damage is fading of dyes and the breakdown of fibers. ULTRAVIOLET (UV) radiation, which is present in natural and artificial light, constitutes the most destructive portion of the light spectrum. Because of the high percentage and intensity of UV in natural light, textiles should never be exposed to DAYLIGHT. Any artificial light source must be filtered to reduce the amount of UV, using, for example, FIBER OPTIC LIGHTING or UV-filtering ACRYLIC SHEETING, such as PLEXIGLAS®.

When on display, textiles should be exposed to the lowest possible light level, generally not exceeding 5 FOOT-CANDLES, and for time periods not exceeding three months. The frequency of exhibition is determined on a case by case basis. Keeping lights on only during regular viewing hours will help to preserve these sensitive objects. In textile storerooms, relative darkness should be maintained by using only a safety light when staff is not present. Objects should be packed so that they are completely protected from light (see Storage section). For study, areas of a textile not being examined should be shielded from exposure by covering with light-proof materials, such as BARRIER paper. In laboratories and work areas where light levels need to be relatively high for examination and treatment, care must be taken to expose only the portion of the textile that is of interest, and for the shortest possible time. At all other times, the textile should be covered with one or more layers of barrier paper, PHOTO-TEX® tissue, or other protective material.

Temperature and relative humidity (RH)

There is a close relationship between RELATIVE HUMIDITY (RH) and temperature conditions. Severe fluctuation of either can provoke chemical reactions causing structural damage, such as embrittlement, or dimensional changes. A rapid drop in temperature can cause condensation. Humid conditions can provoke biological infestation (see Chapter 20 for a discussion of pest management). The recommended RH level for textile fibers is 50%±5%, and the recommended temperature range is 68–72°F, the lower temperature being preferable.

Air quality

Air quality is also an essential factor in textile preservation. Mild air circulation is necessary to reduce the likelihood of biological infestations, but textiles should not be placed near air vents or doors, as air of high velocity can cause rapid damage. Dust and particulate matter are very harmful to textiles. Soot, dirt, and biological debris, as well as pollutants generated by construction materials, cleaning agents, and air-conditioning systems, will accelerate oxidation and cause physical damage that is often not readily evident. Exhibition construction and gallery preparation should be done at least three weeks in advance of the opening date to allow sufficient time for drying and off-gassing of paints and ADHESIVES. To avoid exposure to harmful vapors (VOLATILE ORGANIC COMPOUNDS), any material used in proximity to a textile must be ODDY-TESTED.

General maintenance

Food, liquids, or house plants should never be in the vicinity of textiles—not in work areas, storage, or the galleries, as they might carry or attract insects, dust, or pollen, and could increase humidity and cause damage in the case of accidents.

To prevent dust accumulation and pest infestations, it is imperative to follow a periodic maintenance schedule of cleaning and VACUUMING storage facilities, galleries, and conservation areas, including walls, floors, neighboring VITRINES, and adjacent corridors and elevators. The maintenance of textiles displayed without protective GLAZING is particularly important. Procedures for this must only be undertaken by trained individuals, as fragile fibers can readily be damaged by improper techniques.

Gallery display of exposed textiles

The best protection for a textile on view is that it be displayed in a case or vitrine, or mounted and covered with a box made of acrylic sheeting. However, museum textiles are also displayed without such protection, either hanging on walls or resting on slanted or flat supports. It is imperative that these exposed works of art be protected from dust by cleaning the galleries prior to their installation and periodically cleaning them while on view. Textiles that are not protected by glazing should be exhibited at a distance of three feet or more from visitors, behind a barrier such as stanchions or a platform.

HANDLING

Textiles are significantly affected by improper handling, because they are not rigidly constructed objects and their constituents can be in a weakened condition. Textiles should be handled as little as possible. All handling procedures, whether for transport, examination, treatment, photography, or preparation for installation, must be carefully planned in advance to minimize direct contact with the textile. The safety of the object is the most important consideration. If the supporting materials on which the textile is positioned are properly prepared, these can be handled rather than the work of art. When a textile itself is handled, this may be done without GLOVES in order to have the best tactile sense of the object and thus better control of one's actions. However, NITRILE exam gloves must be used especially when handling pieces that contain metal thread. Clean, dry, lotion-free hands are mandatory. Jewelry, necklaces, hanging bracelets, and

ID cards must be removed when a textile is handled. Both hands should be free, and clean and comfortable clothes and footwear should be worn. Large bags and coats should not be in the vicinity of any textile, and visitors should not be allowed to touch textiles.

Prior to handling a textile, it is important to prepare the workspace and materials to be used, assess the particular needs of the object, determine the number of people required for the procedure, and allow for sufficient time to accomplish the task at hand. Each step along the way is important and needs to be evaluated beforehand. Whether using a work table or the floor, the surface should be clean and covered with paper or PLASTIC SHEETING. When working on the floor, an area at least one foot larger than the textile should be demarcated, and street shoes should never be permitted in this area.

Physical stress during the manipulation of a textile can provoke instant damage: abrasions, breaks, tears, and distortions, all of which can worsen with time and subsequent movement. Before a textile is handled, its construction, condition, and size should be assessed. For woven textiles, one of the basic rules in handling is to maintain the perpendicular relationship between warp and weft at all times. If this original relationship is distorted, the textile should be brought to the attention of a conservator, who will evaluate its condition and determine its conservation needs. For nonwoven textiles, or textiles in which the warp and weft are not perpendicular to each other (for example, in a tapestry with a predominant nonhorizontal weave), the original construction must always be maintained. Thus, for example, to prevent damage to textiles mounted at one end by a Velcro® attachment to a slat, it is important to guard against tilting the slat during any installation process, but rather, to keep it in a horizontal position at all times.

For handling large textiles, such as tapestries or carpets, a team with a designated coordinator is often required, and may include as many as twenty people: conservators, collections managers, storage assistants, technicians, installers, and riggers. **(Fig. 1)** The shared steps in this process may include unrolling the tapestry, attaching the slat along its top, raising the tapestry to the hanging position, and securing it in place. The coordinator must assign specific positions to each member of the team and give precise instructions to ensure that the handling is synchronized and balanced over the entire textile to avoid stress on any particular area.

Fig. 1 Installing a large-size hanging. Photograph by Janina Poskrobko, Department of Textile Conservation, The Metropolitan Museum of Art

Textiles less than four to six feet square are small enough to be kept flat during handling and may be supported by a solid board. If the textile needs to be turned over, it is safest to sandwich it between two solid, light-weight boards (such as FOAMCORE) and to have two people perform the operation with synchronized movements. The same method can be used for transporting or reversing larger textiles that are in fragile condition. For this, more preparation is needed in order to secure the textile between the boards with CUSHIONING MATERIALS and ties. Depending on the size of the textile, three to five people are needed for its handling.

Packing and unpacking textiles for loan

Packing/unpacking is a complex process that needs to be adapted to the object's condition and size, whether it is or is not mounted, and the type of mount in which it is housed. It is imperative that textiles be secured for transport or any type of movement. Consideration should always be given to minimizing the handling that will be necessary when textiles are unpacked and installed on the site of the borrowing location. Labels should provide information about the direction of the object, its position during transport, the packing materials used, and the order in which they are layered.

Materials used for packing for loan must take into account fluctuations in temperature and humidity that may occur in transit, and must offer protection against condensation, liquids, and vibration. If the textile is on a solid support, and has a box

made of acrylic sheeting (such as Plexiglas®) over the surface, the mount should be protected with a soft fabric cover and an ACID-FREE board, then wrapped in TYVEK® and placed in a cradle surrounded by cushioning FOAM material. If the textile is not mounted and it cannot be rolled, it must be packed in an acid-free CARDBOARD box and secured against any movement with cushioning materials, such as a combination of TISSUE paper and felted or quilted POLYESTER fiber. The box must be further contained in a cradle and protected with layers of a dense foam, such as ETHAFOAM®. If the textile can be rolled, the entire package is wrapped in tissue and barrier paper and then in Tyvek®. The ends of the tube are suspended and immobilized in a cradle by using a locking mechanism.

STORAGE

Textiles may be stored in cabinets **(Fig. 2)**, on shelves or racks, contained in closed storage or in exhibition mounts custom-prepared for the condition and shape of each textile **(Fig. 3a, b)**, or in boxes or specially made envelopes supported by a board. The storage facility, the storage units and furniture, and the storage format for a given textile must meet the needs of the particular object's dimensions, state of preservation, and handling requirements. ARCHIVAL materials such as acid-free corrugated board and paper, PHOTO-TEX® paper, Tyvek®, and felted or batted materials made of INERT, nonwoven polyester fabrics all offer good protection from light and dust, and provide the necessary support during storage and handling. To avoid unnecessary handling, wrapping, and rewrapping, a label should be affixed to the wrapper, box, or mount identifying the textile, its orientation in the storage format (such as top, front, face in, or face out), and other pertinent information.

Fig. 2 Textiles stored in the Antonio Ratti Textile Center cabinets, protected with barrier paper. Photograph by Photo Studio, The Metropolitan Museum of Art.

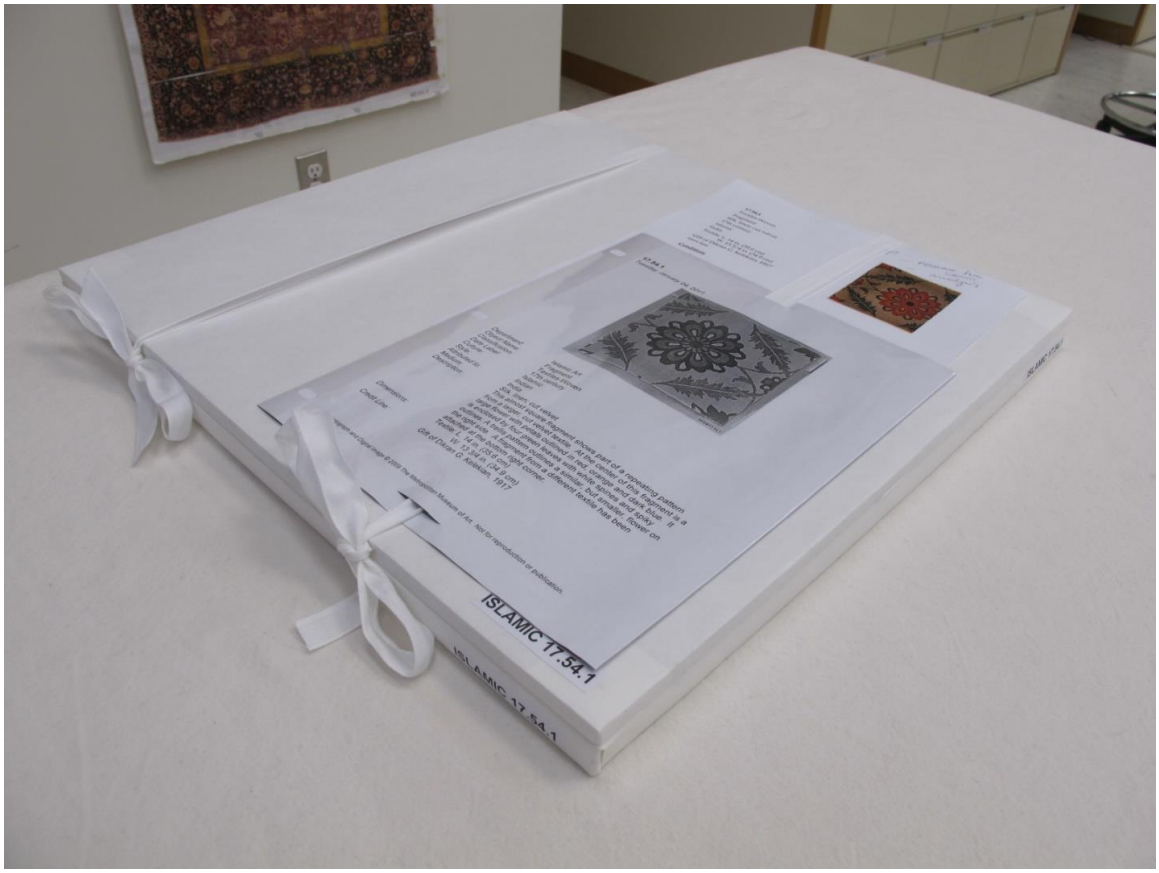

Fig. 3a Storage mount for a flat textile. Photograph by Florica Zaharia, Department of Textile Conservation, The Metropolitan Museum of Art.

Fig. 3b Storage mount including a fabric-covered exhibition display board. Photograph by Florica Zaharia, Department of Textile Conservation, The Metropolitan Museum of Art.

When in shelf storage, a textile may be rolled, wrapped in barrier paper and packed in a cradle, and covered in Tyvek®; or packed in a container made of archival corrugated board. When the textile is stored mounted, it should be protected with an outside cover made of densely woven, thick cotton, sateen-type fabric.

On rare occasion, textiles can be stored vertically or folded. An unmounted textile in good condition that cannot be rolled because of its construction, but is larger than the available storage space, may be stored folded; its folded areas must be cushioned with tissue paper or felted and batted materials made of polyester fibers. Additionally, the textile should be supported by an acid-free board and contained in an envelope made of barrier paper. Vertical storage may be used when no storage options are possible for a permanently mounted, oversized textile. The textile must be in good condition, and the mounting must assure proper support and protection.

TRANSPORT WITHIN THE MUSEUM

When a large textile is to be transported through the museum, the route should be determined by a trial run without the textile. It is best to avoid moving these objects through public spaces when visitors are present, either before or after opening hours. If this is not possible, appropriate escorts are required in front of and behind those handling the object **(Fig. 4)**. For transport, textiles should be put into a manageable and stable format in a box, or covered and, if rolled, wrapped with paper. They should not be

stacked, or mixed with installation materials. They should be transported on a platform that can support the entire textile. If the object requires hand-transport by several individuals, it should not be held directly, but rather the supporting materials in which it is rolled or packed—a tube, a box, or cardboard—should be held. Transport equipment must be stable, and carts must have swiveling, rubber-covered casters, as well as shock absorbers. When a textile is transported horizontally, a solid support larger than the textile or its mount should be provided.

Fig. 4 Transporting art through the Museum's galleries escorted by conservators and riggers. Photograph by Janina Poskrobko, Department of Textile Conservation, The Metropolitan Museum of Art

Suggested Reading

The Metropolitan Museum of Art. *Conserving the Emperor's Carpet*, March 2013. http://www.metmuseum.org/metmedia/video/collections/isl/conserving-the-emperors-carpet

Zaharia, Florica. "The Department of Textile Conservation at The Metropolitan Museum of Art." In *Textiles Specialty Group Post-prints, American Institute for Conservation of Historic and Artistic Works 37th Annual Meeting*, pp. 66–76. Los Angeles: AIC, 2009.

Kajitani, Nobuko. "Care of Fabrics in the Museum," in *Preservation of Paper and Textiles of Historic and Artistic Value*, ed. John C. Williams, Advances in Chemistry Series No. 164, pp. 161-180. Copyright 1977 American Chemical Society.

18. COSTUMES

Sarah Scaturro

INTRODUCTION

Although costumes and accessories might appear easy to handle due to their familiarity, they are actually among the most difficult objects to handle properly. The reasons for this include their nonstatic form, their composite structure, vulnerability to the environment, and their functional purpose. A garment might seem to be in strong condition, but one should assume that it is much weaker than it appears. Unlike many objects, most garments do not have a fixed shape. Rather, they have a collapsed, two-dimensional structure when hanging or folded in a box, but the slightest movement shifts this into a flexible, three-dimensional form. This inherent instability increases the physical risk of damage to costumes whenever they are handled. Additionally, garments are often made of a composite of fabrics and embellishments, each of which has its own potential weaknesses. For example, a garment could be composed of different materials for the exterior, interlining, facing, and even the sewing threads. Costumes may be made of a wide range of fibers that are ORGANIC (silk, cotton, wool, linen) and synthetic (nylon, polyester, acetate), along with additional materials for the ornamentation and closures, and these might range from metal, horn, ivory, and plastics to feathers and leather. Because materials have different aging properties, each component needs to be assessed for condition and stability prior to handling. A garment that might look stable on the exterior could be in an extremely deteriorated condition on the interior.

INHERENT VICE—the inevitable breakdown of certain unstable materials—can be widespread in costume collections. Over time, plastics such as CELLULOSE NITRATE, CELLULOSE ACETATE, and many other synthetics begin to off-gas harmful compounds (VOCS) that can both hasten the object's degradation and damage surrounding objects. Polyvinyl chloride (PVC) and natural and synthetic rubbers can leach plasticizers, becoming sticky or embrittled, while polyurethane can crumble to powder. Weighted silks, manufactured in the late nineteenth and early twentieth centuries, are prone to shattering due to the metallic SALTS and other INORGANICS used in their production.

Another factor affecting the vulnerability of costumes is their inherently functional role. Having been close to the human body, they have undergone rougher treatment than other art objects. Wearing a garment strains seams and degrades textiles. The ACIDIFYING nature of perspiration, a major cause of weakness in many garments, irreversibly degrades fabric. Harsh cleaning methods can distort or damage fibers, while dirt, soot, and stains that are not removed also have a deleterious effect. Previous alterations and repairs can affect the intended shape of the garment, shifting tension onto potentially weak areas; and weakening will be exacerbated by past adverse storage methods and environmental conditions, such as acidic containers, improper hanging, exposure to dirt, dust, pests, and light, or extremes and fluctuations in temperature and relative humidity.

ENVIRONMENTAL CONSIDERATIONS: CAUSES OF DAMAGE

Like textiles, costumes are very sensitive to their environment and should be kept in stable, properly vented conditions, ideally at a temperature range of 68–72°F and RELATIVE HUMIDITY (RH) of 40–55%. It is most important that these levels not fluctuate

drastically. RH should not exceed 65% in order to avoid chemical damage (hydrolysis of polymers and CORROSION of metals) and BIODETERIORATION (mold). RH below 30% can lead to desiccation and embrittlement of fibers, leather, and other materials. Cold conditions are often beneficial. Although inherent vice cannot be stopped, damage can be delayed with stable lower temperatures and RH at about 45%. Should a breakdown in the HVAC system occur, humidifiers, dehumidifiers, and MICROCLIMATES can be used to maintain a safe environment.

LIGHT exposure is also an important factor in the preservation of costumes. Damage from VISIBLE and ULTRAVIOLET (UV) light is cumulative and irreversible, the former contributing to fading and UV contributing to polymer degradation. The object's exhibition history should always be considered when determining whether it is safe for it to be displayed. Light levels for exhibition should be below 5 FOOT-CANDLES and display limited to three to six months. Light should exclude UV and heat. Light-emitting diodes (LEDS) are a good option because of their longevity, different color temperatures, and ability to be dimmed. While on display, garments should be kept behind glass, acrylic GLAZING, or at an out-of-touch distance of at least 36 inches. In storage, protection from light and dust can be achieved by covering garments with single-garment covers or MUSLIN rack covers, placing in cabinetry with doors, or storing in dark areas. Window covers, UV filters, light sensors and timers, and turning lights off when personnel are not present are essential.

Cleanliness is a key aspect in the proper storage of costume objects. Housekeeping should be done regularly, including dusting floors, crevices, and storage furniture. Door sweeps should be applied to all entryways to limit dirt and pests. Storage furniture should be ventilated and covered with clean, unbleached muslin to limit deposition of soot and atmospheric pollutants.

Cleanliness also plays a role in effective INTEGRATED PEST MANAGEMENT. No food or drink should be consumed within the storage or work area, and all trash containers emptied daily. All areas should be routinely monitored for insects with nonpheromone STICKY TRAPS, while pheromone sticky traps are used for diagnosing the extent of a suspected infestation. In the event of an infestation, a licensed pest-control professional should investigate the source, identify the pest, and assist in solving the problem. Infested objects should be immediately quarantined and wrapped in POLYETHYLENE sheeting. Pest-eradication methods must be determined by a conservator. Due to toxicity and potential contamination, chemical FUMIGATION should never be used. ANOXIC TREATMENT is the preferred course of action, but must be carried out by museum scientists or experienced professionals. FREEZING can be harmful to some objects and should be undertaken with caution. Dry cleaning (immersive solvent cleaning) can be effective but depends upon the object's condition, composition, and age.

Costumes can become infested with mold or mildew if RH levels spike above about 60%. Previous infestations and lack of ventilation can exacerbate and increase the likelihood of biodeterioration. If a mold infestation is present, the object should be immediately isolated, with as little movement as possible to avoid spreading spores. If the mold is active, VACUUMING with a HEPA-FILTER, dry cleaning, or localized solvent cleaning are effective for removal. Caution must be exercised when handling the object, as the areas affected by mold are weaker. Proper protective equipment should be used at all times.

Fig. 1 Large or heavy objects require two or more people synchronizing all movements. Photograph by Christopher Mazza.

Fig. 2 When transporting a hanging garment short distances, it is usually acceptable to hold the hanger hook with one hand while supporting the garment halfway down with the other. Photograph by Christopher Mazza.

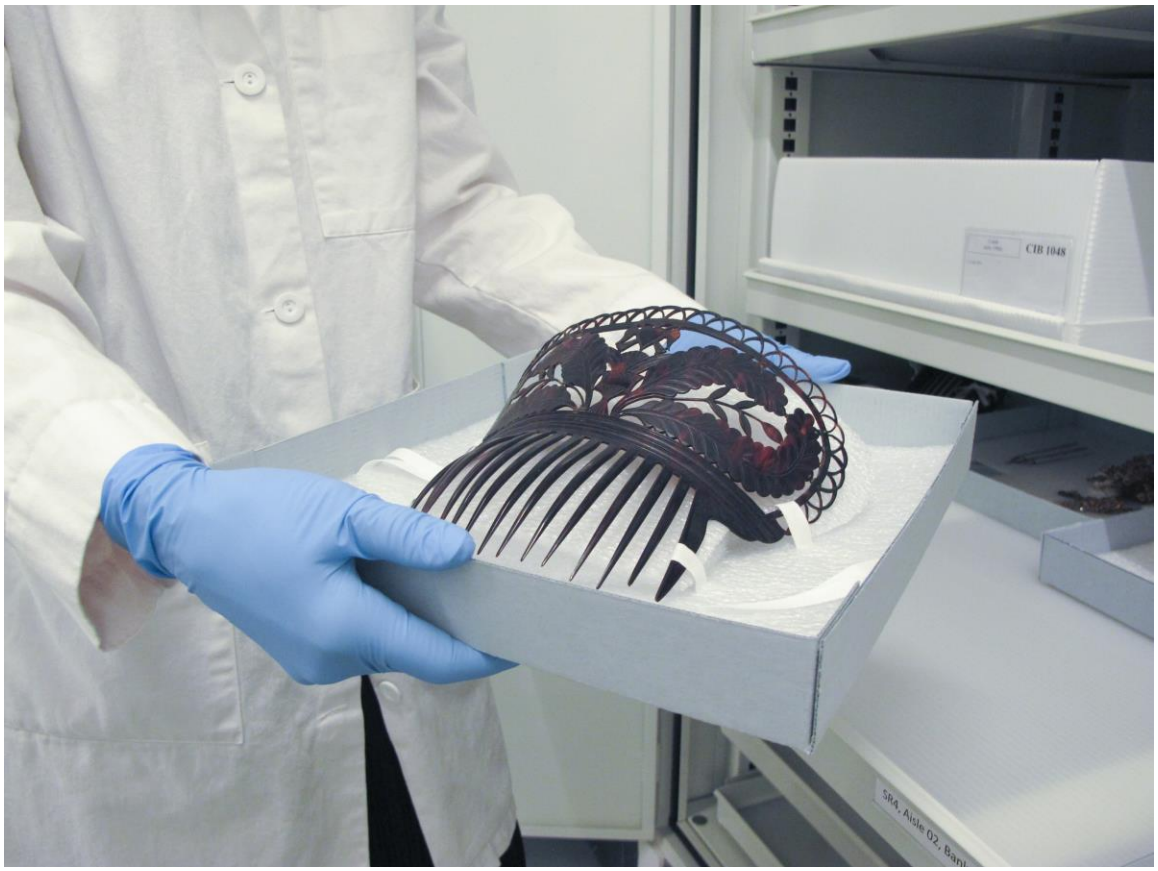

Fig. 3 Padded support trays or boards should be used to transport objects from one location to another. Photograph by Christopher Mazza.

Fig. 4 The key to mounting any costume is to ensure that it is fully supported, including at the arms, shoulders, waist, hips, and skirt or legs. Accurate historical silhouettes often provide the most support and are least damaging to the costume on display. Photograph by Joyce Fung.

Fig. 5 There are two main ways to store costumes – flat or hanging. Photograph by Elizabeth Arenaro.

Fig. 6 To maintain an object's shape, accessories such as shoes should be lightly padded using archival materials. Photograph by Christopher Mazza.

Fig. 7 All boxed and flat storage objects should be transported on an adequately sized cart or rolling shelving unit by at least two people. Photograph by Christopher Mazza.

A safe area for handling costumes is paramount. It should be clean, large enough to support the entire garment, and clutter-free to give full access to it. The table should be lined with a clean, light-colored fabric, such as washed, unbleached muslin or cotton sheeting, pH-neutral PAPER, or washed TYVEK®. An object should never be placed in direct sunlight, and, when the object is not being actively handled, exposure to light should be limited by covering it with TISSUE paper, Tyvek®, or muslin.

Nitrile GLOVES should be used whenever handling costumes and accessories, especially metals, common in buttons, jewelry, and other embellishments. Gloves are also a protection from residues of toxic chemicals (mercury, arsenic, and naphthalene), once used to deter pests. When handling textiles, jewelry and ID tags should be removed; the handler's clothing should be free of clasps, zippers, or hooks, which might snag or tear an object. Only pencils and soft measuring tapes without metal parts should be used near an object. One should never attempt to wear a costume.

The fragility of a costume should never be underestimated. Unnecessary touching can be avoided by planning all actions, the final position, and location in

advance, even determining if space is adequate on a garment rack. The garment must be inspected before attempting any manipulation or movement. Historic clothing often has many hidden closures and other elements, such as weights. Areas of the garment where heavier or stronger materials meet lighter or weaker ones should be supported whenever the object is moved, using pH-neutral tissue as a BARRIER to prevent snagging.

An object should always be handled with both hands, whether moving, lifting, reversing, hanging, or holding it. Large or heavy objects require two or more people, planning and synchronizing all movements. For moving short distances, the object should be placed on a tray or support board, especially if there are doubts about its fragility. When transporting a hanging garment short distances, it is usually acceptable to hold the hanger hook with one hand while supporting the garment halfway down with the other. Its weight should be evenly distributed, no part of the object should touch the floor, and, if possible, it should be covered with muslin or Tyvek®.

Garment closures demand special care. Fastening and unfastening is best done when the object is flat, never pulling the surrounding fabric but using a fingernail to gently pry the two pieces apart. Buttonholes should be worked around the button to minimize stress on the button thread and surrounding textile.

Costume accessories and other three-dimensional costume objects should be handled only by their structurally stable areas. For example, a hat should be lifted by the hatband, not the brim. Purses and handbags should be held by the body, never the handle or strap. All dangling and free-moving elements should be properly supported. PADDED support trays or boards should be used to transport objects from one location to another.

DISPLAY

The display of costumes on mannequins, dress forms, and other mounts is a practice fraught with potential problems. For historical accuracy, it is often critical that the costume be displayed in the round, rather than flat or hanging. Mounting costumes requires an understanding of the garment's construction, size, shape, and condition, as well as the technical aspects of the intended mannequin or dress form that will be used. The size and proportion of the form should match those of the garment. If the mount is too small, it can be padded out using POLYESTER batting covered with washed nylon stocking or cotton stockinette, but a garment should never be dressed on a form that is too big for it. The key to mounting any costume is to ensure that it is fully supported, including at the arms, shoulders, waist, hips, and skirt or legs. Overstuffing can strain seams and cause damage, but the object must have enough support to minimize the effects of gravity while on display. Accurate historical silhouettes often provide the most support and are least damaging to the costume on display. This can be achieved with reproduction undergarments, but original undergarments and structures should never be used.

STORAGE

There are two main ways to store costumes—flat or hanging. Objects that are fragile, in poor condition, heavy, beaded, knit, or have weak areas should lay flat in an ACID-FREE archival box, drawer, or tray lined with washed muslin or Tyvek® (which also serves as a sling for moving the object). An object placed on a lift-out board that fits into a drawer or

tray will require less handling when it is moved to another location. Storage furniture should be POWDER-COATED METAL, not a WOOD product. RUBBER and PLASTIC elements within the storage system should be ODDY-TESTED to ensure that they will not off-gas. Plastic storage containers made of POLYPROPYLENE should be avoided, as they can trap volatile organic compounds (VOCs) that catalyze degradation processes. Objects with sticky surfaces should have a barrier of SILICONE RELEASE polyester film separating them from the storage container. ARCHIVAL boxes can be stacked on wire or solid metal shelving. The shelving should be large enough to fully accommodate the size of the box, and boxes should not be stacked more than two high.

Regardless of the container used, it should be the largest size that will accommodate the object with minimal folding or crowding. If folding is unavoidable, folds should be gently padded with pH-neutral tissue. Stacking garments on top of each other should be avoided, but if necessary, a tissue or muslin barrier should be placed between them. Layers should be kept to a minimum, with heavier and larger objects on the bottom and weaker objects or those with three-dimensional elements above.

Objects that are strong can usually be hung on padded, archival hangers of appropriate size. Hangers should reach the shoulder line but not extend into the sleeve, which will cause fabric distortion and eventual damage. Some garments will need to be secured with twill TAPE, others require felt-padded clip hangers. Racks should be tall enough so that the object doesn't puddle onto the floor. To minimize abrasion and damage, the racks should not be packed tightly, especially when using rolling racks or compact storage. Garments that have a semi-rigid three-dimensional structure do not benefit from boxed or hanging storage and may require mounting on a custom-shaped archival torso form fixed to a stand. This will also ensure support from the shoulders through the skirt.

Accessories should be stabilized on boards or trays using recessed or three-dimensional supports, with loose or dangling elements secured with twill ties. There should be enough space around objects to allow for safe handling of the board or tray without touching the object. To maintain an object's shape, accessories such as shoes, hats, and soft-sided bags should be lightly padded using wadded archival tissue or fabric-covered polyester batting, avoiding overstuffing and abrasive materials. (For rolled storage of textiles, consult Chapter 17.)

TRANSPORT

Large or heavy objects must be handled with two or more people, the route being planned in advance to ensure a clear pathway. All movements must be planned and synchronized. There are two main methods of transport, each closely aligned with storage methods. First, all boxed and flat storage objects should be transported on an adequately sized cart or rolling shelving unit. Garments should be secured in a sling, while three-dimensional objects should be placed inside a padded tray to avoid abrasion and vibrations. All objects should be covered with pH-neutral tissue, washed muslin, or Tyvek® and the cart wrapped in plastic for further protection during transport. Pneumatic wheels and FOAM shelf lining can help minimize vibrations associated with movement. A second method is transporting hanging garments on a rolling rack. The objects should be completely enclosed with a muslin or Tyvek® cover to prevent them from touching the floor or catching in the wheels. It is imperative that the garments are securely held on their hangers and that they do not get caught on zippers when opening and closing the covers.

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19. UPHOLSTERY

Nancy Britton

THE STRUCTURE OF AN UPHOLSTERED OBJECT

All textiles, being ORGANIC materials and often extensively processed, deteriorate as a result of adverse environmental conditions and poor handling, but the deterioration of upholstery is exacerbated by its complex structure and the function it has served in bearing the weight of the sitter. Upholstery is composed of two major components: the visible decorative textiles—the show cover and trims—and the under-upholstery substructure that actually does the work of supporting the sitter and provides the upholstered profile. The under-upholstery, though often of humble materials, is an important component of the object, helping to date it and providing insight into period upholstery techniques and historic profiles. A considerable amount of original under-upholstery often survives beneath a succession of replacements. The under-upholstery consists of several stacked layers of textiles of varying qualities intermingled with a variety of loose fibers, secured together with twines and attached to the seating frames with metal fasteners, such as tacks and staples. The show cover lies on top of the under-upholstered form and is the layer most vulnerable to use and adverse environmental conditions. The under-upholstery profile distorts as its materials, comprising embrittled twine, stitching, and fillings, deteriorate, and it is further damaged by the CORROSION of iron-containing metal fasteners. All the under-upholstery layers are under some degree of stress and compression, particularly when seating incorporates springs, as found in furniture made after about 1800 **(Fig. 1)**. The cyclic compression and extension during use of these diverse materials, and the abrasive action of a sitter's movement, cause the inevitable deterioration of individual components and their integrated relationships over time.

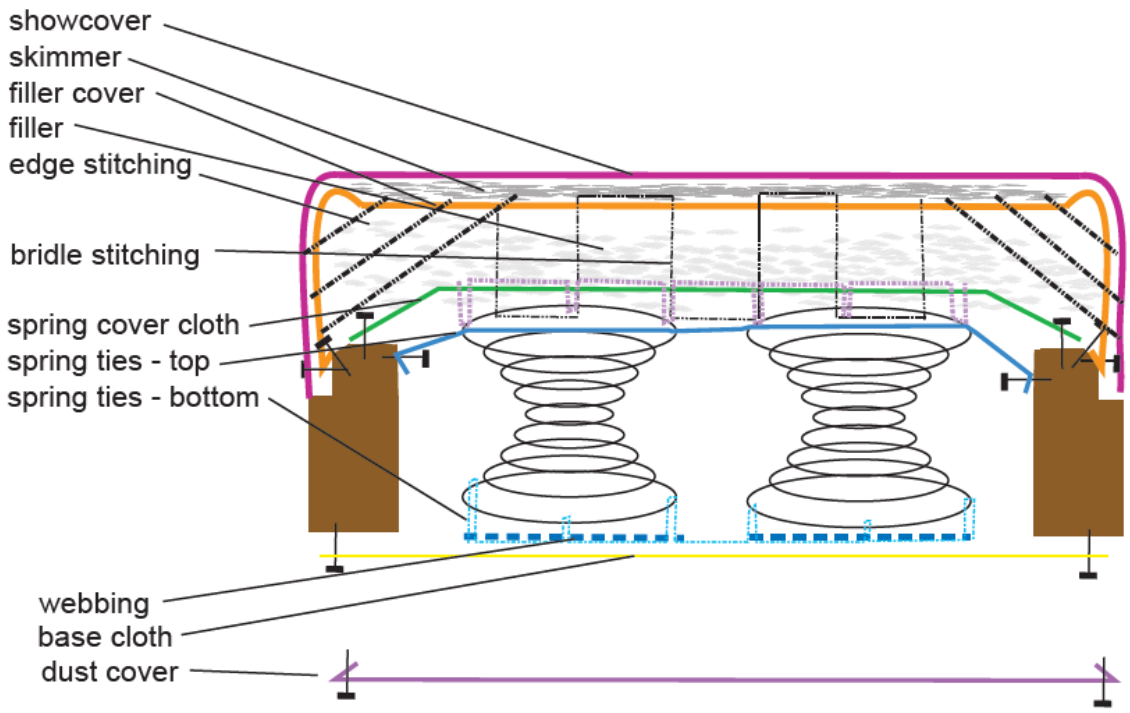

Fig. 1

ENVIRONMENTAL CONSIDERATIONS

As with all museum textiles, the best approach to preserving upholstered objects is PREVENTATIVE CONSERVATION, which involves controlling the environment to maintain optimal conditions, and adhering to good practices in handling, transport, storage, and packing.

All the components of an upholstered object are subject to deterioration, and environmental factors play a large role in this process. As with all organic materials, the components of upholstered furniture are vulnerable to photo-degradation and PHOTO-OXIDATION, both of which are cumulative. Exposure to high levels of illumination for prolonged periods causes deterioration of dyes and textile fibers, but because upholstered furniture is three-dimensional, LIGHT damage is often uneven. To best protect these objects, they should be exhibited at a maximum of 5 FOOT-CANDLES for no more than three months per calendar year.

Having a mix of fibers—varying combinations of PROTEINACEOUS, CELLULOSIC, and man-made synthetics—upholstered objects are often unevenly damaged from adverse temperature and RELATIVE HUMIDITY (RH). Deterioration is exacerbated by short, cyclic fluctuations or sudden fluctuations in either or both conditions. A dry environment can cause desiccation and embrittlement of upholstery fabrics; whereas high levels of humidity can lead to mold growth and INSECT DAMAGE. Maintaining the environment at 50%±5%RH and 68–72°F will provide favorable conditions for their preservation.

Clean air also plays an important role in preserving these objects. Frequently having been in a domestic environment, particulate atmospheric pollutants, ranging from the oils contained in food odors, AIRBORNE dust and soil, soils and fibers brought in by shoes and clothing, to gritty particles from fireplaces and coal-burning systems, also

contribute to chemical and physical deterioration. These pollutants result in films and sticky surfaces or deeply embedded deposits, including carbon particles, settling in the interstices of the textile fibers and abrading and discoloring them. VACUUMING and mechanical removal are difficult at best when this has occurred.

PESTS

Objects that are infested or suspected of being infested should be immediately isolated by wrapping them in POLYETHYLENE PLASTIC SHEETING and sealing the openings with TAPE. The object should be scheduled for ANOXIC TREATMENT as soon as possible. Upholstered furniture is composed of mixed media and the materials are variably sensitive to extreme temperatures, thus freezing for pest management is not generally possible. Objects previously stored in an uncontrolled environment should be preventatively monitored in their new storage location for three months by wrapping in POLYTHYLENE PLASTIC SHEETING, sealing the openings with tape, and observing them for insect activity. Once removed from the bags, the object should be thoroughly vacuumed and inspected. At the conclusion, the vacuum bag should be removed, sealed in a plastic bag and disposed of, and the vacuum hose thoroughly washed. Assessment and advice from a biological scientist is highly recommended for the management of if insect infestations. Insecticides and repellents are not used on these objects.

HANDLING

Handling and moving upholstered objects present the greatest opportunity for damage, thus the diverse conditions of structure and extent of deterioration must be evaluated prior to any procedure. Before handling an object, hands should be clean, dry, and lotion-free; jewelry should be removed. Upholstered furniture should be handled by the lowest, load-bearing horizontal structural elements, such as seat rails. Handling of textile components, particularly fringes and tassels, should be avoided. If fringes or tassels are fragile, they should be secured by the conservator prior to moving the furniture.

Prior to handling or moving the object, it is important to understand how it is constructed by identifying separate upholstery components mechanically secured to the frame using screws, pins, or latches. If loose, these require immobilization or securing prior to moving with WEDGES or fillers, or conservation-grade cotton twill tape. The object should be examined for past damages, such as formerly broken legs, loose crest rails, detaching carving, loose decorative brass nails, or loose trims. These can often be temporarily secured with cloth tapes and fabric bags. Existing damages to the textile components (tears, abrasions, loose webbing) should be noted; some may require stabilization prior to moving. Accessories that sit on upholstered furniture, such as pillows, bolsters, squabs, cushions, or mattresses, should be removed and handled separately.

ROUTINE CLEANING

Routine examination of objects on view and in storage should be undertaken. Cleaning can be scheduled on an as-needed basis to avoid the buildup of thick, hygroscopic dust that traps moisture and encourages pests and molds. Upholstered furniture includes both vertical (backs) and horizontal (seats, arms) surfaces. Seats may have to be

cleaned on a more regular schedule than the backs. Cleaning starts at the top of the object and moves to the bottom: from the crest rails and back to the seat. Because of their irregular shapes and delicate fabrics, upholstered objects should be vacuumed by trained staff. Hard-surfaced vacuum tools must be padded to protect these objects. Screens or traps with two to three layers of fine-mesh netting should be placed between the head and the vacuum tubing, and this trap is to be periodically checked. If upholstery fiber is present in the trap, it means the suction is too high or the deteriorated condition of the textile requires the attention of a conservator. Micro-vacuum tools should be used to access small areas of furniture, and Japanese hake brushes without metal ferrules (or with taped ferrules) should be used to avoid nicking wood elements.

Because of the temptation of visitors to touch upholstered objects, they should be placed at least 42–48 inches from the perimeter of the platform on which they are exhibited, and fragile seating furniture, such as caned chairs, should be placed far from doorways and passageways. In order to avoid abrasion, cording that protects seating from use should not come in contact with the textile.

Steps to limit dust accumulation during display reduce the frequency of cleaning. Airborne particulates are composed of a variety of soils and fibers brought in by visitors on their shoes and clothing, and by minute pulverization of flooring materials by foot traffic. They are recirculated by traffic patterns, air flow, and drafts and deposited on the objects. The heavier particles tend to fall within 18–24 inches of the floor, while the airborne particles and fibers rise to around 56 inches. A significant reduction in particulate accumulation is possible by using solid BARRIERS, such as ACRYLIC SHEETING, between traffic pathways and objects. The height should range from a minimum of 24 inches to the most effective height of 4 1/2 feet.

STORAGE

Storage areas are often used for study and examination of furniture, as these locations have the advantage of being light-controlled and will eliminate the need for excess movement and handling. Nonetheless, it is important that lights be kept very low or are turned off when personnel are not present, and that DUST COVERS be used in storage areas for light and dust protection. These covers should be labeled with the accession number and an image of the object to avoid unnecessary handling. Coverings should be loose, and compatible with the furniture surface; for example, gilded furniture may require a light, slippery rayon fabric, while most objects can use tightly woven cotton MUSLIN, laundered prior to use. When covers need to be impermeable to water, an outer covering of TYVEK® or MYLAR® may be required. When used without an absorbent barrier layer, both of these products may foster unfavorable MICROCLIMATES and condensation under conditions of high humidity that can provoke staining and FUNGAL growth. Of the two, Tyvek® allows for air exchange and is therefore preferred, while Mylar® should be used in short-term situations. Objects covered with such materials need to be checked periodically. It is recommended that all coverings be washed once a year as part of the routine maintenance program.

TRANSPORT WITHIN THE MUSEUM

Upholstered objects should be moved on carts, allowing six inches around all sides of the furniture. Tapes or other methods to secure these objects must be determined by the conservator, as they can cause damage by abrasion. Vibrations and shock can be

significantly reduced by covering the floor and sides of the cart with CARPETING and by equipping carts with rubberized wheels. Furniture with castors can be secured on the cart by using foot cups, carved hard FOAMS, such as ETHAFOAM®, or soft foams, such as VOLARA® or NALGENE®, placed beneath the castors.

Packing of these objects for loan must be designed to avoid securing the furniture by the upholstery components and excess handling, or applying damaging pressure. Because packing needs to be unique to the object's requirements, prepacking must be done by a specialist conservator.

Suggested Reading

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20. PREVENTION, IDENTIFICATION, AND CONTROL OF BIODETERIORATION IN THE MUSEUM ENVIRONMENT

Eric Breitung, with contributions by Črtomir Tavzes (former Museum scientist)

INTRODUCTION

Virtually all art objects and their constituent materials of biological origin are susceptible to chemical and physical biodeterioration—the process of decay caused by biological organisms. Museum materials most susceptible to biodeterioration are wood, paper, ivory, bone, leather, textiles, varnishes, paint binders, glues, and sizes; but stone, metals, and ceramics are also susceptible. Microorganisms (i.e., bacteria and fungi) and insects are the major causes of biodeterioration. In the museum environment, bacterial and fungal spores, which are essentially omnipresent in the air, and insects, which are brought inside by incoming objects, crates, construction projects, supplies, food, and visitors and staff, are nearly impossible to eliminate. This chapter offers basic PREVENTATIVE CONSERVATION measures and treatment options for dealing with museum pests.

AIRBORNE spores are the most common means of bacterial and fungal dissemination in museums. Despite profound morphological differences among bacterial and fungal spores, they share one extremely important characteristic: when attached to a surface at favorable temperature and humidity, they will germinate and give rise to a microbial colony. Because spores contain stored nutrients, a newly formed colony can grow rapidly for several days without an external nutrient source. Rapid colony growth of fungi such as mildews and molds can lead to staining and biodeterioration. Environments with humidity levels well above normal museum conditions can lead to the degradation of CELLULOSE, starch, and other ORGANICS comprising works on paper, textiles, and objects made of wood. HVAC failures, isolated leaks (especially those remaining undetected for several days), and areas prone to elevated humidity, water condensation, and inadequate ventilation create environments conducive to microbial growth.

The majority of insect species that cause biodegradation of materials used by artists thrive at a wide range of commonly set room temperatures and RELATIVE HUMIDITY (RH). They feed on nutrients ranging from animal and plant matter, dust, dirt, and other insects to the constituents of works of art. Insects are a large and very heterogeneous taxonomic group. Some insects, such as the larvae of carpet beetles, primarily feed on PROTEINACEOUS materials, including wool, silk, parchment, leather, albumen layers of photographs, and organic binding material; others, such as silverfish, cockroaches, and book lice, find nourishment primarily in starch and CELLULOSIC materials (e.g., paper, wood, and starch paste). Because of these differences, the means of multiplication, migration, and infestation vary tremendously. In general, there are four stages in the life cycle of an insect: egg, larva, pupa, and adult. Most damage to art objects is caused by larvae, but in several species, the adult-stage individuals are the most voracious eaters.

CONTROLLING BIODETERIORATION: INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is a building-wide, ecosystem-based strategy for preventing damage caused by insects, rodents, microbes, and other life by controlling and monitoring climate, structures, and cultural practices. Implementation of an IPM

strategy requires, at a minimum, vigilance by all staff to monitor and report pests and to maintain a clean work environment. Sightings of leaks, standing water, or condensation points, as well as mold or mildew stains and odors, insects, and animals, must be reported and addressed quickly.

Treatments and abatements to both the building and art should prioritize firstly the health and safety of employees and visitors, followed by the natural environment and art. When chemical treatments are required, human toxicity and environmental persistence must be considered. Consultation with abatement professionals, material and safety data sheets, and scientific literature is recommended to determine the acceptable exposure levels/limits (amount and time) for each chemical. Understanding the chemical's method of transmission and effect on the human body is critical for responding to overdose situations.

Treatment that has the potential to alter the work of art or the artist's intention is never undertaken. Often artists have experimented with a wide variety of materials. Sometimes these materials are familiar or can be determined by analysis; more often they are not known. Before undertaking any treatment to correct fungal or insect infestation, one must understand the diverse constituents of which a work of art is composed, which includes the original components and the conservation materials that may have been introduced, and be able to evaluate the effect of a proposed treatment on those materials. This requires the collaboration of the CONSERVATION SCIENTIST and conservator. Without this information, the consequences of applying a biocide to an art object may be an unintended alteration in its appearance and its scientific content.

Preventative Measures

It is vital to be on constant alert for conditions that may create or accelerate biodeterioration and to be vigilant for signs of active infestation.

- *To prevent microorganisms and insects from flourishing in galleries, storerooms, offsite storage, and conservation areas, relative humidity and temperature must be maintained at levels appropriate to the works of art in that area.* This is the best method for preventing biodeterioration of a collection. In general, 50%±5%RH at 70º±2ºF will inhibit significant fungal growth and spore germination. Depending on the material type, however, cooler temperatures and lower humidity may be required to prevent other forms of degradation (see chapters on organic materials). Insects that degrade works of art, however, can thrive at 70ºF / 50%RH, thus additional factors must be considered in their control. Such an infestation may be triggered when objects accustomed to particular environmental conditions are brought into the museum for the purposes of display, study, or acquisition. Changes in climate can provoke previously inactive and undetected insects to hatch, undergo metamorphosis, or swarm.
- *Maintaining appropriate conditions requires communication among building engineers responsible for the optimal functioning of HVAC systems, conservators, collections managers, technicians, security guards, and building maintenance personnel.* It is important to have a centralized monitoring system with temperature and RH sensors in every area that contains works of art. Problematic spaces, such as along exterior walls (especially those with a northern exposure), spaces with limited air circulation, storerooms with overcrowded top-to-bottom shelving, and areas close to entrances, should be equipped with several sensors to alert personnel to environmental problems. Data collected should be routinely reviewed by museum

engineers and COLLECTIONS CARE personnel to identify and ameliorate unacceptable conditions.

- *All art and materials used near or for the display and storage of art must be thoroughly examined for signs of insects and fungi prior to, or at the point of entry into, the museum.* Examples include construction materials, frames, mounts, mounting materials, packaging, crates, and fabrics. Materials used for any other purpose must also be carefully examined, as the supplier's storage facilities or the method of processing may be a source of infestation. Food or restaurant supplies are prime examples of supplies that should be inspected prior to acceptance. Because thorough inspections may not be possible, careful consideration about the delivery, movement, and storage of food throughout the museum is recommended.
- *Infested works of art and other objects must be isolated and encased* in clear POLYETHYLENE bags and sealed with TAPE. They should be examined by a conservator and a biodeterioration specialist to determine the best course of action. If an infestation is severe, it should be treated prior to acceptance into the museum.
- *All galleries, storerooms, work areas, offices, and corridors must be kept clean to reduce or eliminate infestations.* Regularly scheduled checks and ongoing monitoring are essential. Dust accumulation can promote moisture aggregation and provide nutrients (such as, organic matter, nitrogen, sulfur, and iron) for microbes and insects. Condensation from faulty HVAC systems or rapid drops in temperature can encourage the germination of spores. Overcrowded shelving or objects in contact with the floor or walls can impede air circulation and create unintended microclimates, where RH levels are high and conducive to mold growth. Such conditions need to be corrected by the appropriate conservator or collections manager. Housekeeping, such as dusting and VACUUMING, can help to eliminate potential hazards to the collection.
- *Food, plant, and other nutrient materials must not be allowed in art-containing areas.* Consumption and storage of food in designated areas, rather than offices and work areas, is recommended, and food should always be kept in sealed, secondary containers. Food waste should be allowed only in designated bins that are removed daily.
- *Institution-wide training and reporting policies must be established so that situations conducive to biodeterioration can be rapidly addressed.* Records should be kept by each department as to the nature, location, and corrective actions taken for infestations. Ideally, building-wide maps should be kept with the location, type, and frequency of occurrences.

Recognizing Infestation

Signs of insect damage

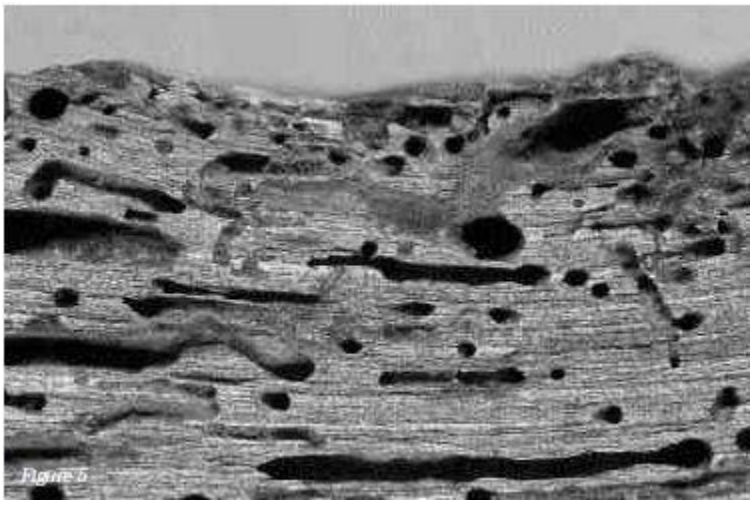

Fig. 1 Tunneling caused by wood-boring insects (in Met Objectives, Spring 2002, v.3, n.2, fig. 5)

Signs of active or previous insect infestations include living or dead insect and remnants of insects (for example, molts, pupal "beds," egg sacks or casings, cocoons, or insect parts), any of which may be found in or on an art object, its supporting material, packaging, or crate. Common signs of past or present insect infestation are FLYSPECKS or excrement and stains; FRASS (sawdust or fragments caused by wood-boring insects) on the surface or falling from wood and paper-based objects; and INSECT EXIT HOLES, tunnels made by wood-boring larvae and adult insects that are common in wood, thick leather, lacquer, stacked paper, and books **(Fig. 1)**. Exit holes that have a light color and sharp edges are generally indicative of recent or active infestation.

Signs of mold damage

The visual clues to fungal infestation are "cottony," threadlike masses, or mycelium, that usually grow in radial colonies on the surface of the infested objects. Mold is a type of fungus (ascomycetes) that is recognized by its colored reproductive structures, which may be black, gray, brown, green, purple, crimson, pink, yellow, or white. The fibrous portion of mold is usually white or translucent. Mold may have a musty odor; however, this is not a criterion for its identification. In storerooms filled with works of art, the "smell of old" is often a combination of VOLATILE ORGANIC COMPOUNDS (VOCs) intertwined with smells of different varnishes, wood, fabric, and other organic materials, making it difficult to pinpoint mold sources.

Highly destructive wood-decaying fungi (mostly basidiomycetes), which thrive under elevated and prolonged periods of damp, are most prevalent in the structural elements of historic buildings but may also be encountered in museum objects. Some species have pigmented mycelium, but the white or colorless form is more common. Wood objects are also vulnerable to brown or white fungal decay, or "rot." The former can be recognized by medium- to dark-brown cubelike structures, delineated by cracks in the wood running perpendicular to the grain, whereas white rot is defined by light-colored or white cellulose fibers that run parallel to the grain of the damaged wood.

Proper Identification Precedes Pest Treatment

The proper identification of pests infested on or in an art object is necessary to devise an appropriate treatment plan. Both phases of the process should be carried out by a specialist. Because insect infestation can occur almost anywhere, it is good practice to monitor the population by placing GLUE TRAPS in spaces where objects are stored or examined. However, glue traps can contain pheromones (insect attractants); to avoid attracting insects near museum entrances and loading docks, traps should be pheromone-free. Pest-management specialists should be consulted to establish the effective range of pheromone traps, which can be placed near interior walls of the museum. Trapped insects can be identified and quantified, allowing assessments to be made as to what measures should be taken to clean the environment.

It is essential to consult an entomologist, mycologist, or biologist at the outset of a problem, rather than a commercial pest-control specialist. Many insects are not a threat to museum objects or the building and do not warrant treatment. In addition, fungal infestations can often be mischaracterized. Treating an object unnecessarily or with the wrong procedure is costly and time consuming, but worse, it has the potential to cause harm to the environment and the art. Determination of the problem often rests on knowledge of insect body parts, or the parts of the fungal reproductive structures. Useful websites for the basic identification of common museum insects in North America are http://www.insectslimited.com and http://museumpests.net. Molds and fungi typically require experts with sophisticated microscopes and scientific equipment for proper identification.

Controlling Biological Infestation

In general, all biocides are reactive products, and many are known to cause alterations in certain types of materials used in works of art. Because of detrimental reactions, many biocides that were previously in common use are no longer used, for example methyl bromide (which may weaken sulfur-containing materials and is unsafe for the environment); ethylene oxide (which causes long-term damage to lipid-containing materials such as parchment and leather, and is toxic to humans); sulfuryl fluoride (which may alter the surface of some painted surfaces); and thymol (which causes discoloration and degradation of paper, parchment, and certain organic pigments and binding media).

A focus of research over the past two decades has been the nonchemical eradication of biological infestations in museum collections. These techniques have included anoxic environments, high or low temperatures, and ultraviolet radiation.

Anoxic treatment

ANOXIC environments are generated with an INERT or nonreactive gas, such as argon, nitrogen, or helium, that is nontoxic to objects and nonflammable. These environments have proven to be the safest and most effective means of treating infested art objects. This treatment process, which is typically completed by a conservator, collections care specialist, or scientist, requires humidity and temperature controls, an oxygen-monitoring system and gas-flow control, and gas-humidification systems. They are, however, the most effective means of FUMIGATION and have no detrimental effects on works of art.

Fig. 2 Anoxic plastic enclosure (same ref; fig. 6)

Anoxic treatment consists of: (1) isolating the object from the ambient (oxygen-rich) environment by placing it in a sealed chamber or PLASTIC BAG (the latter being portable and adjustable to any size object), which maintains a level of less than 500ppm (0.05%) of oxygen **(Fig. 2)**; (2) replacing the ambient air with moist (~50%RH) anoxic (oxygenless), inert gas; and (3) allowing a minimum of three to four weeks for all stages of insect life to expire. The amount of time required depends upon the insect species, the type of infested material, the material density, and its moisture content.

While simple in concept, each step requires an understanding of environmental, physical, and biological factors that may affect the procedure. For example, eradicating fungal infestations on wood or paper objects is more difficult than eliminating insects because of the complicated metabolic role of oxygen in fungal growth and decay. The majority of mold (ascomycetes) species are tolerant of anaerobic conditions, making desiccation necessary. Because desiccation can provoke damage such as shrinkage, delamination, or warping, it is imperative that these procedures be discussed with a specialist.

High-temperature methods

High temperatures are more effective and rapid than low temperatures for insect eradication. Heat, however, is generally unacceptable for use with museum objects because of the potential for damage, especially to organic materials. Wood objects, for example, may undergo desiccation and permanent dimensional changes, such as deformation, warping, and cracking, provoked by a drop in relative humidity as temperature increases. For objects composed of multiple material types, differences in

rates of expansion and changes in surface versus bulk humidity caused by heating may precipitate irreparable damage. Increased temperatures are known to accelerate chemical reactions, which can also significantly affect an object's useful life. A patented methodology, called Thermol Lignum®, which takes all these issues into account, has been successfully adopted in important case studies, but some concerns remain about the effects on media other than wood, such as paint layers and glues, and thus its application must be carefully evaluated on a case by case basis.

Low-temperature methods

FREEZING methods have been extensively employed as a means of controlling insects and fungal infestations in museums, libraries, and archives. The procedure can be effective and economical for large numbers of books and paper-based materials; however, its safety for works of art composed of other materials still requires research by conservators and scientists. Objects made of mixed media may not be appropriate for this procedure because of the risk of bound water freezing within the artifact. Additionally, the swelling that may occur due to changes in a material's relative moisture content during freezing and warming may present structural and chemical problems, putting the object at risk. In addition, unless relatively rapid (less than four hours) and very cold (-20ºF) freezing is achievable, some insects are capable of surviving the treatment.

Ultraviolet radiation

ULTRAVIOLET (UV) radiation, especially at shorter wavelengths, is effective in killing insects. However, because many museum objects are vulnerable to damage from UV energy, this method of pest eradication is generally inappropriate for works of art.

Personal protective attire and the work area when treating infested objects

Fungi in general and molds in particular can be toxic to humans or cause allergic reactions. Conservators working with mold-infested materials should wear protective clothing such as disposable paper gowns, N95 masks, goggles, and nitrile GLOVES. Respirators, face shields, and ear plugs may be necessary for more severe cases. The immediate working area should have an appropriate HEPA air-filtration system, elephant trunks, or fume hoods for evacuation of air with a high particulate count. It is important that these devices and protective clothing be used when infested objects are examined or treated, and, whenever possible, treatments should be completed inside a fume hood or ventless hood designed to draw air away from the conservator or technician and preferably trap particulates in replaceable filters. Vacuum cleaners with HEPA filters specialized for mold removal should be used for cleaning the surrounding area during and following treatment. Vacuum hoses may be fitted with fine nozzles and brushes to aid in the removal of mold from works of art, a procedure that should be carried out under the supervision of a conservator. Work surfaces should be covered with white paper, BLOTTING, or KRAFT PAPER, which should be disposed of after treatment of the mold-infested object. Contaminated objects awaiting, or in the process of, treatment should be wrapped in polyethylene bags and sealed with tape to isolate the infestation.

Suggested Reading

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21. EMERGENCY PREPAREDNESS AND RESPONSE GUIDELINES

Carolyn Riccardelli

An important aspect of taking care of museum collections is knowing what to do in case of an emergency or disaster. Being prepared and having a response plan are essential when a situation demands sound thinking under unpleasant circumstances. Expect emergencies to happen at the most inopportune time. Natural disasters, such as floods, earthquakes, violent storms, fires, or loss of power or terrorism are the first things that come to mind when one thinks of a disaster that can impact a collection. A more common situation is that an emergency will be localized, for example, a leak due to excessive condensation from an air-handling system, water from a burst steam pipe in a storage area, mold growth on a damp wall severely damaging a collection of books, soot deposited on works of art from a fire at a construction site or from faulty wiring in an adjacent gallery.

For catastrophic disasters as well as localized emergencies, it is imperative to design strategies to address them, to both mitigate damage and respond to events. When normal operations fail, an emergency response plan will decrease the amount of time it takes to implement response and recovery procedures, reduce the amount of loss, and increase the amount of material recovered.

The intention of this chapter is to familiarize the museum worker with the fundamental concepts involved in preparing for and responding to emergencies. Disaster planning, response, and recovery are complex operations and well beyond the scope of this manual. These pages present only a summary focusing on personal safety and the basic safety of artworks. The information presented here should be considered the start of an ongoing planning process that each department and the institution as a whole must be ready to put into action. Preparing supplies, prioritizing objects for recovery, developing a list of emergency numbers, and acquiring basic knowledge of emergency procedures—all will help to organize these efforts and get people thinking about such eventualities.

HEALTH AND SAFETY PROTECTION

The first and most important thing to remember when responding to a disaster or an emergency is that human safety is paramount. If ordered to do so, evacuate the building at once and do not reenter until it is declared safe by emergency authorities. Be familiar with fire exists and agreed-upon meeting places. Always have a small flashlight fully charged and fresh batteries at hand. It is essential to remain calm, concentrate on the job at hand, and wait for help from trained personnel to evaluate the safety of affected space. Permission to enter a disaster area may take hours or even weeks to be granted.

While it might be tempting to rush into an emergency situation to remove items from danger, there are hidden hazards that could cause serious injury or even death. Do not touch objects until instructed to do so. Mold, toxic substances in water (such as sewage), hazardous substances in building materials and works of art, and live electrical wires are just a few of the many dangers that might be encountered in an emergency situation.

Personal Safeguards in an Emergency or in the Recovery of Damaged Art

- Any actions taken in removing art from the source of disturbance must be done without risk of personal injury.
- To prevent contamination and to avoid breathing particulate matter, noxious fumes, or allergens, it will be necessary to wear personal protective equipment: a dust mask or respirator, nitrile GLOVES, rubber boots, coveralls, safety glasses, and goggles. Contact your institution's Environmental Health and Safety Manager for additional information on being fitted for and ordering these supplies.
- Do not work alone. Work in teams of two or more.
- Do not carry objects that are too awkward or heavy for your strength. Use proper lifting techniques, and work in teams rather than risk personal injury or damage to the work of art.
- Work carefully and walk slowly, and know your route and destination when handling an object.

EMERGENCY PREPAREDNESS

Know the First Responders

- In an emergency situation, the first contact is your institution's Security Department. Describe your location and the conditions of the emergency.
- Contact the collection conservator, the staff members within your department, and facilities maintenance personnel (for example, plumbers, engineers, custodial staff) who are trained in the proper techniques to be used in emergencies for handling works of art and managing environmental issues. These trained staff will assess the situation, prioritize objects for recovery, and coordinate the response. It is critical to keep an updated list of these contacts in each department as well as with the Security Department. Depending on your institution, the Security Department might be able to make these calls so you can continue with your response duties.
- Do not act alone; rather, follow the established chain of command. Hierarchy is a critical factor in the recovery of damaged collections; knowing this simple fact will help in moving recovery along in an efficient manner. Be prepared to accept supervision.

Know the High-Priority Objects in Your Collection

- A periodically updated master list of priorities should be developed. These priorities must be established in advance by specialist conservators and curators, distinguishing objects by groups based on vulnerability of the materials, value, and importance to the collection (including documentation and libraries), and noting if it is on loan to the institution.
- The list should be kept along with photographs of the objects, a schematic plan of the areas in which they are located (gallery, storeroom, archive, library), a list of case numbers, keys and equipment necessary to access and retrieve objects, and instructions on how to protect objects that cannot be readily moved because of size or special equipment needed. All priority-object information should be kept in a notebook accessible to all potential departmental responders, and a backup copy of

this list at an off-site location that can be accessed remotely. If your institution has a busy exhibition program, the location of priority objects may change regularly. An effective way of maintaining the priority list is to create a distinct priority "package" in the museum database that can be accessed off-site via the web. That way, locations will be up-to-date.

- Objects in storage may be distinguished with waterproof colored labels for easy identification in case of an emergency. These designations will become most useful when developing priorities in the recovery phase following an incident. If it is safe to do so, your high-priority objects are the first candidates to be moved to another location or protected in an emergency.
- Human safety is most important: priority objects are not meant to be pulled from storage and taken out of the building during an evacuation. It is more likely damage will occur to the object and human safety jeopardized if a staff member tries to remove an object in this manner.

Know the Location of Emergency Supplies

- The Metropolitan Museum maintains a Collections Emergency Plan that is distributed to all departments with collections as well as the Security Department. If your institution has such a plan, it should be displayed in a prominent location in each department.
- Know the location of the Collections Emergency Team (CET) Carts throughout your building for the use of first responders on the staff. The CET plan contains updated maps indicating these sites. A diagram and chart of suggested CET Cart contents is given at the end of this chapter.
- In addition to CET Carts, each department should keep emergency supplies available in a specially designated location. Useful supplies include: PLASTIC SHEETING, BLOTTERS, water snakes, gloves, masks and respirators, protective clothing, buckets, flashlights, and first-aid kits. All staff should familiarize themselves with these supplies and where they are stored. The chart below may be used as a guide to collect an inventory of emergency supplies. Additional supplies will be needed as clean-up progresses. It is essential to designate a centralized group of people or an individual to be responsible for maintaining emergency supplies. Depending on the size of your institution, you may want to designate a committee or individual to maintain a centralized source of supplies. Keep in mind that these supplies will most often be used by or under the supervision of persons trained in emergency recovery.
- Restock supplies after use, or notify those who can order and refresh them. It is important to maintain an updated list of suppliers and vendors of these materials.

EMERGENCY RESPONSE

Handling Damaged Art

In or following an emergency, despite one's instincts to immediately salvage damaged artifacts, it is often best to leave them untouched. A fundamental principle to remember for most incidents is to wait for trained personnel to direct the situation before handling objects that have been damaged by water or other circumstances. Although the

guidelines presented in this manual for handling art under normal situations apply to damaged works of art, additional factors will need to be considered. When works of art are threatened by imminent destruction, swift action may be needed and decisions may be required that are not necessarily the same as would be made if time were unlimited. Emergencies and disasters will result in working outside the realm of normal practice. Works of art that have been moved dozens of times will be extremely vulnerable when wet or otherwise damaged. Because of the complexities of the actions that must be taken, it is necessary to have an understanding of basic emergency operations, and to act with tremendous caution. Security managers and guards should be given fundamental training in how to deal with works of art when an emergency occurs at night.

Most disasters and emergencies, including fires, will result in water damage and its aftermath: mold, CORROSION, and pests. Removing an object from the emergency scene to a drier environment without the proper safeguards may cause irreparable damage. Such changes must be carefully controlled to slowly acclimatize the work of art and minimize risk to its structure and materials. For example, a wet mahogany veneered table standing upright in water may appear intact, but its joinery will have significantly weakened and may fail if lifted incorrectly. Even if the table is safely removed from the water but allowed to dry quickly, the veneer may curl and crack. As another example, coated papers and photographic materials will become permanently stuck to adjacent ones if allowed to dry without INTERLEAVING, or become mold-infested if kept in a high-moisture area for more than 48 hours. Water is not the only danger to collections; irreparable damage can occur if one acts too hastily following a fire. Casually wiping away soot from a painting or porous sculpture can cause abrasion to the surface or drive the soot deeper into the underlying structure.

Should an object be damaged in a gallery during public hours, by either an accident or an act of vandalism, the area should be cordoned off to avoid further disturbance by museum visitors. The position of any broken fragments can provide the conservator with clues to their original location; therefore the damaged work of art should be left undisturbed until a conservator arrives on the scene. If the display case or mount is damaged, do not disturb the debris, as a conservator is best able to distinguish between object fragments and VITRINE fragments. Never throw away any such material.

Because some objects will need to be moved, others protected, others secured before any measures can be taken, the instructions of trained staff must be followed when responding to an emergency or recovering works of art in the aftermath. Response and salvage operations will change and evolve throughout the recovery, thus procedures must be accommodated to what is needed as this occurs. These guidelines are offered as fundamental information to be followed in a disaster situation.

Protecting Damaged Objects

- Cordon off the site of the incident. Prevent visitors and unauthorized staff from disturbing damaged objects in galleries or storage areas.
- Unless conditions pose a risk of additional damage, do not move damaged or undamaged objects without being supervised to do so.
- For all types of damage, immediately notify a specialist conservator and other appropriate staff. As soon as possible, document the site and condition of the object with photographs and notes, and indicate the location of the damaged object(s) with floor plans.

- Until recovery operations begin, a good rule of thumb is to maintain damaged objects in the same conditions in which they were found: keep wet items wet and dry items dry. Do not disturb broken objects or fragments.
- If advised by a conservator, undamaged dry objects should be covered with plastic sheeting if there is potential for additional water damage.
- If advised, fans may be set up to increase air circulation in water-damaged areas.

Recovery of Damaged Objects

- Recovery of objects should be accomplished based on predetermined collections priorities and under the supervision of a conservator.
- Use protective garments and equipment; call on experts in handling debris and wiring, or removing standing water. Personal safety is the number one priority.
- Before moving an object, determine all procedures in advance: (1) Determine the manner in which it will be handled. Do not lift it by any projecting parts, such as handles, rim, or arms. (2) Determine a safe, dry location to place it that is out of the way of traffic. (3) Determine the route to reach the destination.
- Never pull, push, or drag a dry or wet work of art; always lift it (but not by a projecting part) with two hands or with the assistance of another person. Providing an underlying support will often help to move damaged materials.
- Only when advised, collect all fragments and broken pieces of damaged objects. Label and store these safely in a box or tray.

Water Emergencies

- Any actions taken in removing art from the source of disturbance must be done without risk of further damage to the object.
- Wet objects will be heavy and weak and can easily fall apart, thus picking up a wet object will require planning all phases of the procedure in advance. If it can be avoided, do not touch the wet parts. Localized areas on the object may have softened due to moisture, and decorative elements may have loosened. Despite appearing to be sound, the joinery or previous repairs will likely have weakened when wet. The fibrous structure of paper-based objects and textiles may have lost their integrity and will need additional support to be moved safely.
- Provide underlying support for damaged wet objects. Do not assume any wet object (painting, paper, archaeological metal, ethnographic artifact, or textile) can bear its own weight. To aid in transport of a weak wet object, use a rigid supporting material, such as a board or tray box, or cloth or plastic sheeting for textiles.
- If water has infiltrated a gallery or storage area, first remove undamaged objects from the floor, then from shelves. Move objects away from damp walls and windows. If possible, removal to dry locations should be done within the first 48 hours after the emergency to prevent mold and bacterial growth. Mold will spread rapidly and damage many types of artwork.
- When advised to move damaged or wet objects, they should be placed on absorbent material (such as blotter paper, blank NEWSPRINT, ACID-FREE paper, paper towels). These absorbent materials may also be used for interleaving or structural support. FREEZING or on-site dehumidification may be recommended in order to stabilize the objects and prevent mold growth.

- Remove wet display, housing, and storage materials (such as carpets, fabrics, CARDBOARD) to help reduce the potential for mold growth and contamination of the environment.

Professional Assistance

Depending on the magnitude of a disaster, you may require the assistance of outside professionals for water removal, cleaning, decontaminating and dehumidifying, and freeze-drying. A list of disaster response consultants and companies should be compiled and regularly maintained.

COLLECTIONS EMERGENCY CART: SUGGESTED CONTENTS (Fig. 1)

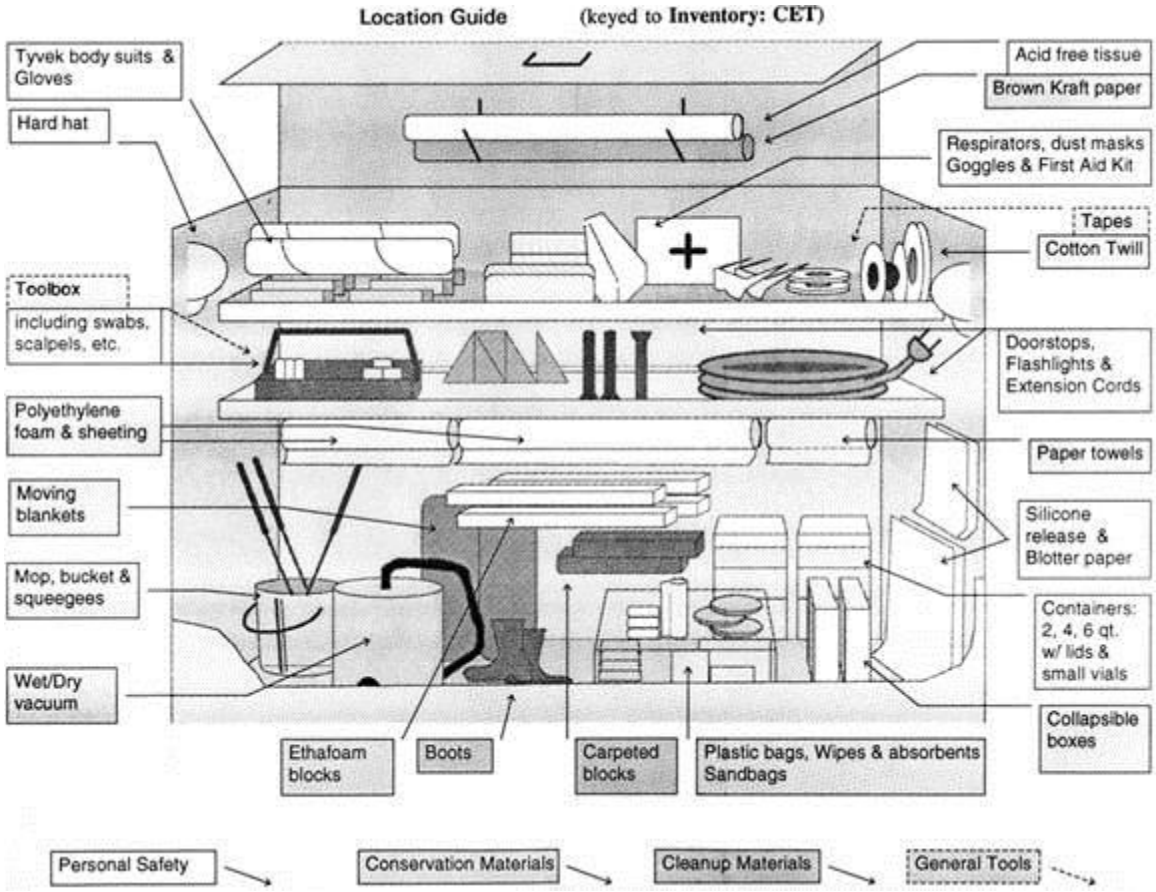

Fig. 1 Diagram of typical CET cart supplies.

SUGGESTED INVENTORY OF SUPPLIES FOR EMERGENCY CARTS

Personal Safety	Absorbent Materials	Materials for Moving, Protecting, and Interleaving	General Tools and Supplies	Documentation Supplies
Rubber boots NITRILE gloves Goggles Dust masks Chemical respirators First aid kits Flashlights Hardhats TYVEK® suits	Spill-control snakes Mops and buckets Paper towels KIMWIPES® Sponges Squeegees	Plastic sheeting Moving blankets Brown KRAFT PAPER Garbage bags SILICONE RELEASE PAPER Polyethylene FOAM sheet MYLAR® Cotton blotter, paper towels, wax paper Ziploc bags ID tags PLASTIC containers Collapsible plastic boxes	Fans Extension cords Wet/dry VACUUM Utility knives SANDBAGS Various ADHESIVE tapes Cotton twill tape Rope Scissors Screwdrivers Batteries	Pens and pencils Permanent markers Notepads Camera

Suggested Reading

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Dorge, Valerie, and Sharon L. Jones, comps. *Building an Emergency Plan: A Guide for Museums and Other Cultural Institutions*. Los Angeles: Getty Conservation Institute, 1999. See “Protection of Art in Emergency Situations,” pp. 252–54.

Emergency Response and Salvage Wheel. Developed by the Heritage Emergency Task Force.

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22. ART IN TRANSIT

Rebecca Fifield

Protection of art in transit within the museum is not just the responsibility of the handler. From the engineers who oversee the environment to staff who share the corridors, all contribute to the safety of art on the move. Art moves within the building for various reasons: it travels to photography studios and conservation laboratories, to packing offices in preparation for shipment, and, most often, between storerooms and galleries. Each of these trips heightens the risk that damage may occur.

CREATING AN ART-SAFE ENVIRONMENT

The preservation of artworks depends upon having an “art-safe” environment. Design and maintenance of nonpublic corridors critically affect the transport of art through them. Good LIGHTING and adequate clearance around turns are important for areas through which art moves. Visibility mirrors mounted at corridor intersections allow art handlers to see any obstacles or traffic around a corner. Level and smooth flooring significantly reduces the vibration of art on carts. Wide corridors and approaches to elevators, though appealing for storage of equipment and carts, should be left free. If corridors are necessary for storage, lines can be marked on the floor to delineate storage space from travel lanes. Similarly, freight elevators, which are shared for the transport of art, construction materials, foodstuffs, and more, need to be kept clean, and free of stored objects, even if only temporarily. Climate control is also of vital importance for an art-safe environment. HVAC systems in good working order help to prevent rapid changes in temperature and RELATIVE HUMIDITY (RH) as art moves through various building zones. A staff vigilant in quickly repairing any breakdown in this system keeps levels appropriate for maintaining the collection in good condition.

Carts, Straps, Padding

The size, configuration, and weight of an object to be transported will determine the number of technicians required for the moving operation, the type of vehicle used, and the STRAPPING and PADDING needed to secure the work of art. Two technicians should move a work of art that one person finds even slightly difficult to manage alone. Similarly, large loads on carts and side trucks should be transported by at least two technicians: one to steer and one to serve as a spotter for obstacles and traffic. To avoid jarring, shock, and vibrations, the cart should be moved slowly, lifting it over door saddles, elevator openings, and uneven ground.

All vehicles for transporting works of art within the museum should have yellow and black diagonal stripes taped along their sides or borders in order to be immediately recognizable. The choice of vehicle—side truck, flatbed, dolly, pallet jack, or cart with or without raised edges—is based on which allows for the most secure placement of the artwork. The vehicle should never be overloaded. Objects should be balanced according to size and weight, and safely padded and secured. Not least, it is important to be certain that the vehicle is stable and allows for easy maneuverability.

Most works of art that are prepared for transport are padded and/or strapped. Padding serves to reduce vibrations and absorb shock. Some recommended types of

temporary padding include ACID-FREE tissue, SANDBAGS, and POLYETHYLENE FOAM sheeting and blocks. The choice will depend upon the configuration and weight of the object and the materials of which it is composed. The same criteria are used for strapping, which serves to secure an object to the transport vehicle. Soft cotton strapping is used for large sculpture; cotton twill TAPE is useful for smaller objects.

Positioning Works for Transit

Before handling any object, the need for and the type of GLOVE suitable for the material must be determined based on the characteristics described in this manual or in discussion with a specialist conservator.

Large objects

Large objects (such as sculpture and reliefs, large armor, furniture), which may require the assistance of riggers to move, are best transported in their most stable position, generally the direction in which they are viewed; however, they may need to be laid down horizontally for increased stability. They are secured in place with nonabrasive padded straps and/or padded in hollows to increase the points of contact with the vehicle (see chapters in this manual for handling and moving specific types of objects). When removing large objects from the transport vehicle, they should be lifted, not dragged, and not placed directly on the floor. If possible, large objects should be stored on platforms with protective surfaces (see PADDING in glossary). If this cannot be done, they should be stored outside of high-traffic areas on wooden skids. Rolled textiles should have support structures at either end of the tube so that the weight is born by this external structure, not by the work of art.

Small objects

Small objects (sculpture, decorative arts, urns, and other vessels) should be transported on securely rimmed carts, rather than being hand-carried, especially if they are to move through high-traffic areas. If a small object is hand-carried, it should be transported in a padded container with a secure handle, and must not extend beyond the confines of the container. As with large objects, positioning depends upon the center of gravity: some objects, such as urns or basketry, may need to be upside down to place the greatest weight or width at the bottom, or positioned with areas of greatest strength bearing the most weight. They may require pads or WEDGES to prevent rolling and vibration, and to protect them from contact with neighboring objects. These objects should never be lifted by their projections, which often do not support weight. Small objects traveling through public spaces should be covered with PAPER, TYVEK®, or similar soft, flexible material so that they are out of view.

Large framed works

Large framed works (paintings, pastels, paper-based art, framed textiles, and empty frames) travel face out on side trucks and are secured with soft cotton straps. Caution should be exercised when strapping delicate, gilt, or ornate frames, which must always

be handled with NITRILE gloves. For works extending beyond the dimensions of the side truck, additional pieces of wood should be secured to the truck to extend the support and prevent damage to the back of these objects. To prevent damage from abrasion, CARDBOARD, FOAMCORE, or similar material is placed between stacked framed works, and should also be placed in front of the outermost object for its physical protection and to reduce attention to its presence. To lift and move a framed work of art, two hands should be used, placed on opposite sides of the frame. A frame should never be handled by its projecting ornamentation, and a framed work never carried by its stretcher. Fingers should never be inserted between the stretcher bars and the canvas.

Small framed works

Small framed works can be transported horizontally on carts; flat frame moldings can be stacked with foamcore or cardboard separators larger than the dimensions of the neighboring works. The topmost object should always be covered with cardboard or similar material to protect it from scratches or breakage, and to reduce attention to its presence. Carts are preferred to hand-carrying, especially in high-traffic areas. If a small framed piece must be hand-carried, it should be held face in and with two hands. A second person should accompany the transport to open doors and ensure that the route is safe to travel.

Unframed works

Unframed works (unmatted works on paper, small framed pastels, miniatures, fragments, and graphic art) should travel flat and face up in SOLANDER BOXES or in trays with rims and moved on carts. In general, nothing should rest on the surface of these works. If the media is known to be stable, an INTERLEAVING of RAG BOARD or ARCHIVAL paper may be placed between each object in a stacked pile, or the objects may be placed in a folder. If an individual object or stack is to be handled, it should be checked in advance that a supporting, underlying sheet of rag board is present to serve as a means of lifting.

ART TRANSPORT SAFETY AWARENESS

In order to reduce the risk of damage or danger to art during transport, it is critical that all staff members and art handlers be aware of safety procedures. In addition to planning the route and preparing the work of art and vehicle for the move, art handlers must always be alert to events occurring in museum galleries and corridors through which they are traveling. Museum passageways are filled with visitors and staff walking to get to their own destinations. High-traffic areas include shops, offices, restaurants, and cafeterias, the main hall, and entries to corridors. Art handlers should know when traffic is likely to be the heaviest in museum corridors, such as at lunch hours, breaks, staff changes, or when special events are taking place, and try to avoid transporting art during those times. Attention should be paid to email notifications regarding elevator shutdowns or temporary blocks of corridors used for art transport to allow alternate paths to be chosen prior to setting out. Vigilance in ensuring safe pathways for art transport is critical.

Art transports should have right of way in the building over other services, such as stock deliveries, restaurant services, and employees getting to their jobs. Some people may rush to get past a transport cart, which usually moves slowly to limit vibration to the object, but pedestrians sharing the corridor with art handlers must be alerted so that a dangerous situation is not created. Carts or handlers carrying art should always be given adequate space and allowed to go first when the space is tight. Mirrors should be used at corners, or a handler should walk in advance of the cart to assess the situation in the passageway, or call out to negotiate around corners where sight may be limited. Carts that carry large works of art may impair the sight of the driver and create a potential hazard, thus an extra person is needed to direct oncoming traffic and to look ahead for obstacles. When a pathway is obstructed by pedestrians, it is the art handler's responsibility to courteously direct them to wait for the cart to pass, or to allow them by if it is safe to do so. Staff carrying food—which should never be in open containers—should stop and hold the food away from the transport until it has passed. If an accident does occur and a work of art is damaged, the Security Department and a departmental representative should be contacted immediately. If that is not possible, any nearby staff member should be asked to get help so the cart is not left unattended.

Safety awareness can be heightened by clear signage in high-traffic corridors reminding museum staff that their actions directly impact the safety of artworks. Good communication—memos, email messages, video instruction for new personnel, and refresher courses for long-standing art handlers—also helps to increase safety awareness. It is equally important that all persons operating other equipment, such as restaurant and construction carts, are made aware of the many unprotected walls, doorways, and architectural elements in the museum and that they must always travel with extreme care.

23. ART IN TRANSITION: THE REGISTRAR'S STOREROOM

Willa Cox and Chuck Agro

A museum's responsibility for ensuring the intrinsic well-being of artworks extends to all activities related to the entry or departure of objects from the building. In the Metropolitan Museum, Storeroom One, an area managed by the Registrar's Office, is the point and place of transition. Here objects are prepared for removal to another location, such as a loan to a museum or return to a lender, or are processed upon arrival. Works in the latter group include Museum objects returning from an outside exhibition, or incoming objects belonging to other collections that have come to the Metropolitan for exhibition, study, or acquisition. Following months of negotiation, each will remain in this active storage facility for only a few days, where they will be examined, documented, packed, or unpacked, employing the same care and handling practices that are applied to works in galleries and curatorial storerooms.

ENVIRONMENTAL CONSIDERATIONS

In order to safeguard works of art from damage due to shifts in climate conditions, Storeroom One maintains the same temperature (68–72°F) and RELATIVE HUMIDITY (RH) (50%±5%) levels as the galleries and permanent storerooms. An incoming object requiring particular climate conditions is immediately brought to the attention of the specialist conservator so that a MICROCLIMATE can be made for it, or it is placed in the curatorial department's storage space. LIGHTING is relatively subdued at about 20 FOOT-CANDLES; FLUORESCENT LIGHT is ULTRAVIOLET-filtered, and there is no DAYLIGHT, but as in departmental storerooms, light-sensitive material is covered. Any incoming work of art showing signs of INSECT INFESTATION—which can occur in many types of materials but most often in textiles, ethnographic objects, wood objects and frames—is immediately rewrapped and covered with POLYETHYLENE sheeting and TAPED closed to prevent contamination of other works of art. It is then brought to the attention of the respective curator, conservator, and pest-management scientist. A clean and dust-free environment is maintained in order to preclude such sources of deterioration.

LOG-IN AND EXAMINATION

All works of art and all component parts or mounts entering or leaving the Museum are digitally logged in and out: Museum objects are designated by their accession numbers, non-Museum objects with a number assigned by the Registrar's Department. Paperwork identifying the work of art accompanies all objects while in Storeroom One. The documentation for a non-Museum object consists of an examination report, a digital image, and a record as to how it was packed. Museum objects are accompanied by a condition report, information about the loan venue, and dates of delivery or departure. Care should be taken to use pencil for reports if ink presents any risk of accidental damage.

The condition of all works of art in Storeroom One is individually evaluated by a registrar or conservator. In preparation for packing and transport, a work of art leaving the building is given a final check based on the conservator's report. Objects not in the collection that are entering for loan, study, or acquisition are examined and digitally

photographed; Museum objects returning from an exhibition elsewhere are inspected to determine that there have been no changes in condition since their departure. These condition assessments, carried out with task lamps and in raking LIGHT prior to and after transit, are descriptive in nature, not diagnostic. While long-standing damage is noted, the focus of these examinations is on recent damage owing to conditions that might have occurred in transit or from handling, such as minor scuffs or breaks, or those provoked by adverse environmental factors, such as undulations or water stains. Any concerns observed by the registrar staff are immediately brought to the attention of appropriate conservators and curators.

For special exhibitions, unpacking and examination often take place in the designated exhibition gallery, as will the outgoing examination prior to repacking. Only authorized personnel—registrars, curators, conservators, and the couriers from the lending institutions—may carry out these procedures. For objects coming to the Museum from a neighboring vicinity, the condition examination will often take place in advance at its off-site location.

HANDLING

To a greater or lesser extent, objects entering or leaving the Museum require handling, touching, lifting, and moving. While the registrars responsible for dealing with the complexities presented by the great array of objects that enter and leave the Museum are experts at this task, their practices are based on the established guidelines outlined in this manual, ongoing training, and the advice of specialist conservators. Handling standards in Storeroom One are the same established methods as practiced by the curatorial and conservation departments: whether this be using two hands to lift a small vase, having two or more persons move a large and heavy table (over 25 inches wide or over 75 pounds), not holding a vessel by its lip or handles or carrying a chair by its arms or turning a drawing face down, and the many other circumstances that arise on a daily basis. To do so safely, works of art are assessed prior to handling to determine points of weakness, and whether GLOVES are required. Many materials are sensitive to the heat and moisture of hands and skin oils, or are otherwise fragile, and therefore require this protection. If gloves are not appropriate, hands should be washed and thoroughly dried before any action is taken. Surfaces on which objects are examined, stored, or moved—tables, shelves, side trucks, and transport carts—must be examined in advance to determine that they are clean and free of debris. To ensure safety, all handling procedures are planned in advance, including the movements required, the transport route within the storeroom, and the type and location of storage. The component parts of an object should be lifted and stored separately. Disassembly of artwork, if required, should only be done by a conservator. If an object is damaged, the appropriate registrar or conservator should be notified. In all cases, the safety and safe storage of an artwork is the first priority, after which documentation is carried out.

PACKING

The objective in packing a work of art is to stabilize and protect the object from vibration, unsuitable environmental conditions (water, extremes and fluctuations in relative humidity and temperature), unsafe materials, and physical damage caused by handling or impact. Packing works of art is a complex procedure, as each object presents its own particular requirements based on its materials, condition, weight, size, and configuration,

as well as the type and duration of travel. Packing and unpacking is done only by specially trained registrar staff, often in consultation with conservators. Packing materials must be appropriate for the materials and surface characteristics of the artwork. As indicated in the various chapters of this manual and in the glossary, these materials must be INERT or chemically stable so as not to damage or provoke degradation by abrasion, snagging, moisture retention, or off-gassing, and must protect objects from vibration in transit. Instructions for specialized packing (for example, if the object is to ride flat or be packed in polyethylene, etc.) should be sent to the Registrar's Office when the preloan condition check is done. This information should also be recorded on the Museum database for future reference.

Whether boxed (soft-packed in CARDBOARD) or crated, a work of art should have minimum contact with its packing material, and no direct contact with the primary packing container. A packed work of art should not be physically compressed by the packing materials. It must sit on a surface that can CUSHION and hold its weight, but these materials should not be compressed by the weight of the object. Isolating the object from the container is achieved by securing it at its sides with braces, guillotine locks, FOAM blocks, or TISSUE rolls. In the case of simple soft-packs that are often used for relatively small and light-weight framed objects, layers of PAPER, PLASTIC, or cardboard protect the work of art from hand pressure. This packing is not sufficient to protect the object from vibration, thus it is used only for local travel in the immediate vicinity. Proper packing also requires clearly displayed identification numbers on the exterior and interior of the crate, and digital photographs so that the object can be repacked in the exact manner at the close of the loan exhibition. The final stage of packing is observed by the courier who will travel with the work of art in order to become familiar with the object's orientation in the crate and the packing method. Once packed, the outgoing crate is properly secured and padded in the transport vehicle and ready for departure.

UNPACKING

The unpacking of an object should be given great consideration when planning the packing process. Packing should be clear, uncomplicated, and easily removable. Photographs recording the sequence of packing should aid in this process. Objects should be packed so that undue pressure is avoided and sharp tools will not be required to remove the packing materials. All packing materials should be carefully examined for small parts, broken pieces, or mounts. Packing material should not be discarded until the condition report is completed. While unpacking works of art belonging to other institutions, the method and materials must be recorded and digitally photographed so that the object can be repacked in the same manner. Packing materials and crates for non-Museum objects are labeled and stored for reuse. If any damage is observed during unpacking, or anything seems amiss, the process should be immediately stopped and a conservator notified: in some instances, damage can worsen by additional handling. A conservator should be alerted if packing material has adhered to the surface of the artwork, in which case no attempt should be made to remove it by other personnel. Similarly, if an object appears broken and held together by the pressure of the packing, or if any damage, such as a hole, tear, or water stain, is visible on the outside of the packing, a conservator should be notified.

TEMPORARY STORAGE

All works of art, and all component parts or mounts, entering or leaving the Museum, whether they are outside objects or works of art from the collection, are stored for a brief period of time in the Registrar's storeroom with their designated identification number and other documentation while they await the procedural steps of examination, packing, or unpacking. For safety and to allow for immediate access, the art storage unit is labeled and numbered, and its location and the object to be stored in it or on it entered in a log. Similarly, the receiving area (a large space holding full crates that have just arrived or are ready to leave the Museum, or recently emptied crates) is well organized, with clearly marked pathways on the floor to allow for immediate identification. Every box or crate is labeled with a green "empty" tape or a red "full" tape.

Storage is also determined by the size and weight of the object. Large objects (such as furniture and framed paintings and works on paper) are kept on platforms elevated above the floor to protect them from inadvertent cart or pedestrian traffic. Medium-size objects are kept on tables with protective lips at the edges. Small objects are kept in closed, POWDER-COATED METAL cabinets designed for art storage on shelves lined with secured NALGENE® sheeting. Medium-sized and small framed and unframed works on paper and pastels are kept in flat files, always face up. Framed works on paper, oriented so their hinges are at the top, can also be stored in vertical slots. Unframed works on paper too large for the drawers are stored on tables with a protective covering of FOAMCORE or BARRIER PAPER. Framed paintings in good condition that are not subject to damage from vibration and have secure hanging hardware are stored on movable racks. Very small objects and objects made with precious materials are stored in locked cabinets in a vault located within the storeroom.

Upon completion of unpacking, documentation, and condition reporting, incoming works of art are removed and signed out from Storeroom One by curatorial department technicians for Museum display or storage.

24. STOREROOM MANAGEMENT AND ORGANIZATION

Rebecca Fifield

Storage of collections is not a passive activity, but an active one that is a crucial part of a museum's preventative care program. Works of art on display in galleries generally represent only a small percentage of the holdings of an institution. While safeguards for these objects include stable mounting, appropriate materials for display, avoidance of exposure to VISIBLE and ULTRAVIOLET (UV) illumination, and maintaining optimal environmental conditions, additional factors must be considered in the storeroom, where agents of deterioration and risks to works of art can be very different.

Establishing policies and procedures for the maintenance of art in storerooms is fundamental to sound PREVENTATIVE CONSERVATION practices. Poor storage methods and unsuitable storage locations can lead to irreversible damage that cannot be remedied by interventive treatment. Prudent COLLECTIONS CARE storage policies should be directed toward providing a stable environment for objects—whether they remain in storage on a short- or long-term basis—and safe handling and access to the works of art. All aspects of the facility's design and furniture should be integrated with methodical maintenance and monitoring procedures.

LOCATION

The ideal location for museum storerooms is on a main floor. Locating a storeroom in a basement or on the top floor subjects a collection to specific risks. Basements can flood from plumbing and clogged drains, and are subject to rising damp. They often have high or fluctuating levels of humidity and high incidences of pest activity. Attic and top-floor spaces are prone to roof leaks and dangerous levels of heat. Yet, even when the storage location is optimal, objects should be kept away from doors, windows, or exterior walls. Doors and windows can give access to pests as well as present security risks. Windows and skylights pose problems of heat and exposure to NATURAL LIGHT, while rising damp in exterior walls can damage objects in proximity to them and adversely affect overall climate conditions. Similarly, sources of water, including plumbing and steam pipes, pose risks to works of art, thus storage areas should be situated far from these hazards. Fire suppression systems, such as ceiling sprinklers, are the only water sources that should be located in collections storerooms. Although such systems are often perceived as a water hazard, accidental discharge is rare and can be further prevented by regular monitoring. Wet-pipe sprinkler systems, generated by smoke detectors, are effective in suppressing fires quickly and efficiently. They can save a collection from complete incineration, deter significant building damage, and, most importantly, prevent the loss of human life.

In addition to location, access to the storage space is also an important consideration. Door height and width must accommodate the dimensions of all objects that will be placed in the storeroom. Approaches to a storeroom must allow handlers and transport carts to make turns: a tight corridor angle just before the storeroom door will prevent a large object from being wheeled or carried into a storage area. Easy access to elevators is imperative, as usually the storeroom is not located on the same floor as the galleries, photography studio, conservation laboratories, registrar's office, and other areas to which the collection regularly travels.

THE STORAGE ENVIRONMENT

As discussed throughout this manual, reduction of deterioration agents is essential to the preservation of stored and exhibited collections. Maintaining temperature and RELATIVE HUMIDITY (RH) conditions at stable levels is among the highest priorities. These levels should be determined by conservators based on the particular requirements of the objects in storage. For example, for wood and other ORGANIC objects, storage should be in an area where it is possible to limit fluctuations in RH in order to prevent dimensional changes (such as warping, or detachment of veneers or paint layers), which over time lead to structural weakening; for diseased glass or compromised metals, maintaining low RH (about 35%) will halt further deterioration and CORROSION. For some objects, the safest storage may be in MICROCLIMATES. In all storage areas, air circulation is imperative to prevent stagnant air, and to discourage mold growth and insects.

Another factor in creating a safe storage environment is the elimination of VOLATILE ORGANIC COMPOUNDS (VOCs) and other pollutants that can accelerate deterioration. Air pollutants should be filtered through the HVAC system; however, VOCs—noxious vapors that accelerate deterioration of organic and INORGANIC objects—are exuded from many types of synthetic and man-made materials. An informed selection of all elements in a storeroom thus can contribute to the preservation of the objects contained in that space. This includes construction materials, such as for flooring and ceilings, the type paint, and storage cabinets. Architectural details must also be considered in making the environment safe. Drop ceilings should not be installed in storerooms, as the enclosed space can harbor dust and pests and conceal leaks. Similarly, joins between the wall and floor are key areas for the entry of pests, thus seamless floor and baseboard units should be used. All doors to storerooms should be fitted with brush gaskets and/or tracking mats to limit dust and insects from entering the space.

Illumination is a key component in storeroom management. While LIGHTS are often turned off or set at a reduced level when there is little activity, it is important that sufficient bright overhead illumination be available when a work of art is moved, handled, or examined. DAYLIGHT should not be present, FLUORESCENT LIGHTS should be fitted with UV filters, and heat-generating lamps should be kept at a distance from works of art. Objects that are sensitive to light or incorporate components that are vulnerable to such damage should be covered with BARRIER PAPER or other suitable opaque material at all times, including when they are resting on work tables or carts.

ACTIVITY AND WORKSPACES IN THE STOREROOM

Ideally, storerooms should be used exclusively for the storage of collections; however, many other activities are often carried out in these areas depending upon curatorial needs, ranging from exhibition preparation, mount making, and examination to storage of necessary supplies. Office spaces within storerooms often invite food and beverages, as well as lint-laden materials inappropriate to areas that must be kept clean. Many of these activities can generate dust and debris and introduce pests, thus limited activity should be encouraged in order to maintain an optimal preservation environment. Examination and photography carried out in storerooms can be advantageous in avoiding transport and the risk of physical damage to an object. Any examination surface, whether a table or cart, must be able to support the weight of the object, and PADDING, WEIGHTS, WEDGES, or other supports should be readily available to prevent its movement.

COLLECTIONS CABINETRY AND OTHER STOREROOM FURNITURE

Properly surveying collections to assess the condition of objects and the required storage formats prior to their rehousing or reorganization will best inform cabinetry selection and the use of the allocated space. Numerous types of storage furniture are available commercially or custom-designed, and may include wire screens for hanging framed objects, racks for large rolled textiles, flat files or drawers, and open shelving. Compact cabinetry, which can be adapted to all types of objects, maximizes storage space but can only be used when the floor-loading capacity in the designated area is strong enough to accommodate the weight of this system. Cabinets should be finished with durable and INERT, POWDER-COATED epoxy. WOOD and COMPOSITE WOOD, unless sealed according to conservation standards, should not be used for storage of artworks. Closed, gasketed cabinetry prevents dust from settling on the works of art, limits the introduction of pollutants and insects, and resists water in the case of a flood or from sprinklers during a fire. Objects that are too large to fit in cabinets should be placed on raised platforms at least 6 inches above the floor, or on industrial racking units, thereby reducing the risk of damage from routine cleaning (such as bumping from a VACUUM), insects, or floods. Works of art stored in the open need DUST COVERS, the type (such as MYLAR® or POLYETHYLENE sheeting) suitable to the object's surface characteristics. Framed paintings, depending upon their condition, may be kept on movable or stable racks. Unframed prints, drawings, and pastels are stored in SOLANDER BOXES, which are constructed to block out light and dust and are sectioned into compartments, ARCHIVAL cardboard boxes are suitable for small objects.

Many factors need to be considered in selecting storeroom cabinetry and its arrangement. For example, passageways between storage units must be sufficiently wide to accommodate transport carts carrying paintings, boxes, or large objects; swing space must be allowed for cabinet doors. In storerooms with high cabinets, tall ladders or hydraulic lifts are often required to shelve and retrieve objects, thus cabinet doors must be designed to swing past the ladders and the people on them. In determining storage locations, works that require two art handlers should be stored at lower levels for safe access. The proper choice of ladders, stepstools, and other furniture is essential to preventing falls, repetitive stress injuries, and unnecessary risk taking, and to protecting the works of art. Taking each of these factors into consideration requires the collective input of storeroom managers, art handlers, and architects.

ARRANGEMENT OF OBJECTS WITHIN THE STOREROOM

Objects in a storage facility are stored according to curatorial practices. They are organized according to various criteria, including size and format, material or type of object, geographical origin, or other factors that reflect how the collection is accessed. For example, large rolled textiles such as quilts and barkcloth, though of different type and origin, require rack storage, thus are kept in the same location but arranged by type. Prints and drawings in Solander boxes are arranged by country of origin, size of the storage box, and alphabetical listing by artist. In storerooms with diversified collections, similar types of objects are kept together, such as sculpture on open shelves, furniture in compact units, small boxes in drawers, and miniatures in closed cabinets.

Storage decisions are also based on PRESERVATION requirements, allowing for the particular environmental needs of organic and inorganic objects. Although objects of similar composition usually have identical requirements, there are many exceptions: for example, composite objects demand conditions that favor the most vulnerable

component, and metals that share the same need for low RH cannot in all instances be in proximity to metals of different types because of damaging reactions that could occur (see Chapter 1). Extremely RH-sensitive materials, such as parchment or ivory miniatures, may require a microclimate for storage. Similarly, objects that are known or suspected of having been treated with toxic PESTICIDES should be separated from other works in the storage facility to avoid contaminating them, and should be marked with warning information. When in doubt, the advice of a specialist conservator should be sought to clarify these issues.

Placement of objects within storage furniture also must take into consideration how those objects will be reshelved and retrieved. Heavy or difficult to handle objects should be placed in waist-high or lower cabinets. Lighter objects might be placed on higher shelves. Care should be taken to organize objects on shelves or drawers so that they can be easily retrieved with the minimum of handling, thus stacking or placing one object behind another should be avoided. Only inert and ACID-FREE storage and supporting materials appropriate to the object's composition and texture should be used. Long-term contact with unstable or ACIDIC materials can have severely damaging consequences. Identifying objects and their supports with the accession number, a photograph for boxed or covered objects, and tracking information can reduce the need to handle objects and thus lessen the risk of damage.

STOREROOM POLICIES AND PROCEDURES

While it may seem that a collection in storage is at rest, it requires staff vigilance for its protection. A mix of monitoring and maintenance activities are required as part of a program of preventative care. Storerooms, especially those in which objects are infrequently accessed, should be monitored daily for any signs of leaks, infestations, broken locks, inappropriate temperature and relative humidity, musty odors, and other unstable conditions. This rarely involves more than a brief walk-through each morning. Storerooms should be regularly cleaned with a HEPA vacuum cleaner. Brooms should not be used, as they recirculate dust into the air. Occasionally wet cleaning of floors may be performed, but this should be limited, as it raises the humidity of the storage space. INTEGRATED PEST MANAGEMENT (IPM) must be carried out in all storage spaces. The use of GLUE TRAPS, monitored at least monthly, allows insect activity to be determined. Once a normal baseline is established, increases in insect populations can be tackled using mitigating strategies, such as more frequent cleaning, keeping trash in sealed containers and regularly removing it, closer examination of objects and mounts for infestation, and ANOXIC TREATMENT if necessary. All data on insect captures should be documented to evaluate ongoing pest counts and management efforts. Because of the constant movement of art and storage materials through the museum, IPM should not be confined to storerooms, but rather must be understood as an institution-wide commitment to a pest-free environment and sound preservation practices.

25. MUSEUM LOANS

Katharine Baetjer, Aileen Chuk, and Marjorie Shelley

Art objects are subject to risk each time they are handled, moved, transported, and exposed to variations in atmospheric conditions or prolonged or excessive LIGHT. In order to ensure the optimum state of PRESERVATION, the same conditions required in the Metropolitan Museum must be adhered to when objects are exhibited at a borrowing institution.

PRELOAN CHECKS

Museum loan regulations require that objects be in suitable condition for travel and for exhibition at another institution. This is determined by the conservator in consultation with the curator prior to the curator's official recommendation of the loan. The conservator will indicate on the appropriate forms that the object has been examined and approved for loan. A thorough condition report (on a form specific to the type of object) documented with photographs is necessary for the loan to be processed.

BASIC LOAN CRITERIA

The following factors should be taken into consideration in determining loan recommendations:

- The structural or compositional fragility of the object: Does its condition make it vulnerable to climatic changes, light exposure, or vibration and movement that might occur while in transit or on view?
- The object's exhibition history: Has the object been exposed to repeated periods of light exposure, vibration, and handling in transit and packing?
- Duration and type of loan: Will a long-term or traveling exhibition subject sensitive material to excessive light exposure or the hazards resulting from repeated packing and unpacking?
- Size and weight of the object: Are there packing and/or shipping issues that pose problems for structurally complex objects or objects that must be shipped in a particular orientation, or issues related to physical condition such as dimensions, center of gravity, weight, projecting parts, insecure attachments, or surface features? Are special packing materials required to protect delicate surfaces?
- Dimensions of the crate must be sufficiently large to be seen in the airport palleting facility and by fork-lift operators.
- Facilities of the borrowing institution: Do the environmental conditions, guardianship, fire security, and other factors comply with standards determined by the conservator, curator, and registrar?
- Transport within the borrowing institution: The width of passageways and door frames and any potential obstacles in the borrowing institution must be known in advance of packing to allow crates to be transported without reorientation and subjecting the object(s) to extra movement.

CONDITIONS OF AGREEMENT

Objects are loaned only to institutions whose environmental, security, and safety conditions are known to the Museum and comply with its standards. Facilities reports from the borrowing institution are required each time a loan is requested specifying its physical conditions, ability to regulate climate and lighting, type of guardianship, security measures, and availability of personnel who are capable of dealing with the complexity of a particular object or packaging, among other factors. These reports are available from the Registrar's Office or will be requested from the borrowing institution for first-time loan requests. Loan agreements are based on the borrower's agreement that it will respect the Metropolitan Museum's specifications for humidity and temperature levels, lighting, security, fire protection, and display; that the objects will not be unframed or dismantled; and that all damages will be reported to the Museum immediately. Specific questions regarding the Museum's conditions governing the loan of objects should be directed to the Registrar's Office.

It is the responsibility of the curatorial departments and the specialist conservators to specify care and handling instructions, such as the required light and climate levels, the orientation of crated objects, the method by which very small objects are to be secured to a wall or in a VITRINE, and whether particularly light-sensitive objects may or may not be photographed while on loan. This information is to be specified on the loan form.

LOAN RENEWALS

Renewal of long-term loans is done biannually so that the conservator and curator may decide if the loan is to be continued. Among the factors to be taken into account is the likelihood of damage to an object from prolonged light exposure or unfavorable climatic conditions.

COURIERS

In addition to accompanying loans and ensuring their proper handling in transit, couriers have the responsibility of observing their installation at the borrowing institution, as well as their unpacking and packing. Couriers who are present at the installation of loan exhibitions must be aware of requested light levels and other conditions specified by the Museum, and should ensure that these are respected. Detailed instructions are available from the Registrar's Office.

26. GUIDELINES FOR PHOTOGRAPHY OF ARTWORKS

Barbara Bridgers

Until recent times, the major concern associated with the photography of artworks was the potential for heat and light damage that could occur during the set-up period and in shooting. Unlike traditional or analog photography, which used hot lights high in ULTRAVIOLET (UV) radiation, the lighting sources and digital equipment used today have eliminated these particular hazards in the professional photography studio. Avoiding the problems that result from mishandling and accidents still depends upon careful and thoughtful attention during and surrounding the photograph session, the security of camera parts and stands used on the set, and maintaining optimal environmental conditions in the photo studio.

ENVIRONMENTAL CONSIDERATIONS

Temperature, RELATIVE HUMIDITY (RH), and air circulation in the Photo Studio and its storage rooms should be maintained at the same levels as in galleries and curatorial storerooms, between 68–72°F and 50%RH. Should there be a malfunction in the HVAC system, photography should be postponed.

Photographic Lighting

Materials that are known to be sensitive to LIGHT, heat, and handling should not be repeatedly photographed.

At present, four types of light source are used for digital and traditional photography, the choice depending upon the configuration of the object:

- Strobe or electronic lights: for all three-dimensional objects of all types of material. They emit an instantaneous flash with minimal heat and negligible UV light if properly filtered.
- HMI lamps: for scanning flat works on paper. These lamps generate a negligible amount of heat and UV light. Exposure for several minutes is required.
- LED lights: used for works on paper. They are similar to HMI lights but do not generate any heat. Typically, LED light sources emit minimal INFRARED or UV light.
- Light bars: for copy work. These FLUORESCENT LIGHTS emit minimal infrared light but have a high UV component.

For the photography of artworks for study purposes in storerooms or on copy stands when HMI or strobe lighting is not available, the following guidelines should be followed:

- To protect the work of art, basic guidelines for handling discussed in the various chapters of this manual should be practiced.
- To protect from light and heat damage, digital cameras without flash (intended for low-light photography) should be used.
- When using conventional photographic lamps, light intensity should be maintained at as low a level as possible. For heat and light-sensitive objects, exposure should be

limited to three minutes, then lights turned off for at least two minutes or directed away from the object. Lights should be turned on only for focusing, taking light readings, and for shooting. Lights should be kept off when not in actual use.
- To minimize danger from accidents and to reduce the effects of heat, lights and all accessories should be kept at as great a distance as possible from the object being photographed, and from neighboring objects.
- Set-up time should be kept to a minimum by arranging objects, photo lamps, and stands in advance of turning on the photographic lamps.
- For light-sensitive objects, electronic flash should be used whenever possible; for extremely sensitive objects, one should use indirect lighting by bouncing light off adjacent white surfaces or diffusing it through tissue or other material.

Handling Art Objects during Photography

- The strategy for set-up, transport, and handling of the object to be photographed should be planned in advance of carrying out the procedure. Familiarity with basic handling guidelines described in this manual is essential. Training and assistance should be requested when necessary.
- Fragile or problematic objects (for example, those made of multiple parts) should be accompanied by specific instructions for their handling. If necessary, a conservator, technician, installer, or curator should be assigned to handle them.
- Requests for multiple views and details should be noted on photo orders, but restraint should be exercised given the resolution of studio captures—most details can be extracted from an overall image. In some instances, the person responsible for the order may need to be present during the photography session. Given the nature of the photographic project, views may be limited.
- To minimize handling of artworks while in the Photo Studio, storage trays, boxes, or baskets should accompany objects, and SOLANDER BOXES should accompany works on paper. These containers should be used in moving the work of art to and from the photography set, and while the object is in storage.
- NITRILE or cotton GLOVES should be worn when handling sensitive materials such as metals and lacquer (see Chapters 1 and 9). Gloves should fit well, and not be fibrous or have grips. Cotton gloves should be clean to avoid transferring soil. The appropriate conservator should be consulted when in doubt.
- More than one person is required to handle large and heavy objects. The assistance of a technician, conservator, or another photographer should be enlisted.
- At the Metropolitan Museum, to assist photographers in handling works of art according to best practices, it is required that they take training sessions upon commencement of employment (which may be periodically repeated) from members of the various conservation departments.

Handling Equipment

- Works of art should be placed on the set only after the camera and set material are fully prepared, or prepared to the greatest extent possible.
- Careful attention should be given to the position and security of all objects on the set: the work of art, lights, and card stands.

- Before positioning an object, the surface upon which it should rest and the background material must be secured.
- A work of art that needs to be propped up or otherwise secured should be handled and positioned only by persons familiar with that type of object. A conservator, technician, installer, or curator should be consulted or, if necessary, be present, if the object is problematic or to offer guidance in the best method of securing it.
- For overhead shooting, the photographer must ensure that lenses and filters are well secured to the camera for attachment, using tape when necessary for this purpose. A camera lens should never be adjusted or changed directly above an object.
- Whenever possible, the camera, and not the object, should be moved to attain the proper angle and focus.

PHOTOGRAPHERS UNDER CONTRACT

The Museum's Photo Studio does not engage freelance photographers. Contractual photographers engaged by curatorial, editorial, or other Museum departments must provide information to the conservator or curator as to the type of lighting that will be used. The photographer is expected to follow Museum guidelines. A curator or conservator should be present to handle objects being photographed by an outside photographer and to ensure compliance with Museum guidelines. Contractual photographers are responsible for all post-production and editing of their final images.

For safety of the artwork, television, film crews, videotape projects, and press photographers must contact the Communications Department (212.879.5500, X3441) for Museum guidelines regarding the equipment and the type of lighting that is permissible to use. The Museum reserves the right, at its sole discretion, to withhold or withdraw permission to photograph objects.

The curator or conservation department should be contacted to determine if any special lighting restrictions are applicable to the material being photographed.

VISITORS TO THE MUSEUM

For the long-term safety of artworks, the use of flash, movie and video cameras, and selfie-sticks is not permitted. Tripods may be used only by special permission. Inquiries should be directed to the Information Desk.

Still photography is permitted for private, noncommercial use only in the Museum's galleries holding the permanent collection. Photography is not permitted in special exhibitions, of art from other institutions or on loan from private collections, or in "No Photography" designated areas.

Note

An important global trend in recent years has been the adoption of objective, standardized capture practices. There are currently three primary methodologies:

U.S. Federal Agencies Digitization Guidelines Initiative
http://www.digitizationguidelines.gov/

The Metamorfoze Preservation Imaging Guidelines
National Library of the Netherlands, 2012
https://www.metamorfoze.nl/sites/metamorfoze.nl/files/publicatie_documenten/Metamorfoze_Preservation_Imaging_Guidelines_1.0.pdf

Warda, Jeffrey, ed. *The AIC Guide to Photography and Conservation Documentation*. 2d ed. Washington, D.C.: AIC, 2011
http://www.conservation-us.org/resources/our-publications/special-projects/the-aic-guide#.V-2Z9aIrJGx

The AIC guidelines are the least technical.

While there are minor differences between these regional best-practice documents, they are all based on the use of technical targets and measurement of imaging performance criteria as a form of quality assurance and quality control. There are efforts underway to unify these regional best practices as an ISO (International Standards Organization) document.

27. ENVIRONMENTAL GUIDELINES FOR PRESERVING WORKS OF ART: RELATIVE HUMIDITY AND TEMPERATURE

Marjorie Shelley

Even in a museum, works of art are not immune to deterioration. Adverse climate conditions can compromise the structure and appearance of both ORGANIC and INORGANIC materials, and much environmentally induced damage cannot be reversed. Preserving objects—slowing the inevitable aging process to a minimum—can only occur within controlled parameters. These include maintaining a stable RELATIVE HUMIDITY and temperature range (RH/T) on a daily basis with only moderate year-round variations; avoiding extremes and fluctuations in these conditions; eliminating gaseous pollutants and particulate matter with air-filtration systems; controlling the quality and amount of LIGHT; guarding against mold and pests by cleanliness and air circulation; and ensuring that objects are housed and displayed in a manner suited to their properties.

Relative humidity and temperature are among the most critical factors in preserving works of art in storage and on display. While it is not possible to fix an absolute standard, or one ideal climate level applicable to all works, maintaining an environment appropriate to the type of object is critical to its chemical and physical stability.

Organic materials are highly vulnerable to high RH levels and rapid climatic changes because they are hygroscopic: they absorb and release moisture in relation to atmospheric conditions (also known as the equilibrium moisture content) and thus are subject to expansion and contraction and consequent structural damage. Target levels of approximately 50%±5%RH and 70°±2°F are suitable for the preservation of paper, wood, parchment, ivory, plant fibers, and other works in this category. Other organic objects, such as lacquerware and Asian screens, require a slightly higher RH of about 55%. In some instances, a broader range may be acceptable; in others, it should be tailored to the object's specific needs.

Many inorganic materials (stone, metals, glass, and ceramics) in good condition can tolerate a broader RH and temperature range without risk. Compromised inorganic materials, such as archaeological metals, SALT-laden ceramics, BRONZE-DISEASED objects, and WEEPING GLASS, however, are subject to ongoing deterioration unless kept in an environment of about 35%RH. Drier conditions are similarly required for photographs in good condition.

While gradual changes in RH are acceptable, extremes and fluctuations should be avoided. Above 70%RH, there is risk of damage to most objects, for example rust formation on iron, insect activity on paper, mold growth on leather, or an increase in the corrosive effects of air pollution. Below 40%RH, organic materials give up moisture, which can cause desiccation and structural alteration.

RH is of greater consequence than temperature; however, both factors must be considered together in protecting objects from structural damage, chemical change, and BIODETERIORATION. High temperatures will accelerate rates of reactions, such as the degrading effects of air pollution, metals CORROSION, desiccation of wood, and damage from light. Whereas cold temperatures will prolong the life of many organic materials and are thus desirable for certain objects (for example, photographs and books), in an enclosed space, such as a GLAZED and framed drawing or a sealed crate, a rapid decrease in temperature will be accompanied by an increase in RH, resulting in condensation. These droplets of water forming on surfaces that are colder than the

surrounding air can lead to corrosion, staining, and mold growth. An increase in temperature can cause RH to drop to dangerously low levels, resulting in a loss of moisture from the object that can provoke warping and shrinking of wood, embrittlement of textiles, splitting of ivory, FLAKING of paint, and other damage.

The two major considerations in creating a safe display and storage environment for works of art are knowing the properties of the object, and the suitability of its display and storage environment based on those properties.

KNOWING THE PROPERTIES OF THE ARTWORK

- *Determine the object's primary constituents:* whether it is composed of organic or inorganic materials, its structure, its condition, and the conditions to which it has become acclimatized.
- *Determine the secondary media.* Most works of art are composites of materials, or mixed media, and each component differs in its sensitivity to RH. *The RH level for these works should be a compromise targeted to the most sensitive or vulnerable component, i.e., the element least adaptable to a range of climate conditions.* This may include attachments, decorative elements, repairs, and adhesives. For example, climate conditions for armor made of leather and iron should generally favor the iron.
- *Note the components of groupings of objects*. Like a composite work of art, the display and storage conditions of *mixed groupings of organic and inorganic materials* should be at an RH level that is a compromise targeted to the most sensitive or vulnerable object that is least adaptable to a broad climate range. For example, when wood and metal objects are displayed together, a lower RH favoring the metal is preferred; when lacquer and paper are displayed together, a higher RH favoring the lacquer is suitable; for a grouping of stone and basketry, preference should be given to the higher RH needs of the basketry.
- *Be aware of the exhibition or storage history of the object*. Objects acclimated to the RH and T levels of their previous environment should be displayed and stored under the same conditions in the museum to avoid dimensional and structural damage. Any changes in climate should be introduced slowly. For example, Egyptian textiles long contained in cool, dry tombs are best preserved in a drier atmosphere such as 45%RH; Asian folding screens, composites of paper, wood, adhesives, and metal, acclimated to a cool, humid environment, should be kept at approximately 55%RH.

28. ENVIRONMENTAL GUIDELINES FOR PRESERVING WORKS OF ART: MAKING THE ENVIRONMENT SAFE

Marjorie Shelley

- *Inspect galleries and storerooms on a routine basis,* but particularly when there are fluctuations in climate conditions, breakdowns in HVAC systems (which can cause rapid shifts in relative humidity [RH] and temperature [T]), or in galleries when humidity levels rise owing to high visitor attendance. Inspections should focus on materials prone to condensation and mold (such as framed and GLAZED pictures), and dark corners with stagnant air and areas prone to dust collection. Dust (particulate matter composed of textile fibers, hair cells, insect parts, pollen, and mineral particles) attracts moisture, which in turn is conducive to mold growth and insect activity.
- *Monitor RH* in VITRINES, galleries, storerooms, and all areas where art is present and corridors through which art travels on a daily basis with HYGROTHERMOGRAPHS, digital recording systems (for large spaces) and DIAL HYGROMETERS, HUMIDITY INDICATOR CARDS, and wi-fi and bluetooth systems (for small or enclosed spaces). For potentially problematic areas, monitoring may be needed several times a day. All devices should be routinely calibrated or checked for accuracy, and the measurements documented. Unsatisfactory conditions should be immediately reported to the specialist conservator and museum engineers overseeing HVAC conditions.
- *Maintain climate conditions* appropriate to the objects on display or in storage year round, and at the level at which a particular object is acclimated. Keep fluctuations in RH and T to a minimum at all times.
- *Create a favorable environment.*
    1. Air condition and ventilate storage and display areas to help maintain desired climate levels and to aid in the removal of gaseous pollutants and dust, and in the reduction of mold and insect activity.
    2. Avoid display or storage near heat sources, including direct sunlight, proximity to INCANDESCENT or HALOGEN lighting, or radiators. The heat generated will lower RH in the surrounding atmosphere, endangering the object by causing it to lose moisture.
    3. Avoid storage in the vicinity of water pipes, air ducts, and vents, or in areas of noncirculating air.
- *Employ sustainable strategies* when possible that minimize the carbon footprint while still providing optimal conditions. For example:
    1. MICROCLIMATES are a cost-efficient means of displaying and storing highly sensitive objects requiring a particular RH level that cannot be met in the large space of a gallery or storeroom. These tightly sealed containers (cases, frames, etc.) can maintain the desired level with BUFFERING agents or conditioned SILICA GEL. (The amount of silica gel is about 2% of the volume of the enclosed space.) Microclimates should be constructed of durable materials that are ODDY-TESTED. They should be opened or replaced after several years to prevent the accumulation of VOLATILE ORGANIC COMPOUNDS (VOCs), which will cause degradation of the enclosed object.

2. *Display and store objects together that can tolerate wide ranges of RH and T*, such as stone and porcelain, in order to minimize fuel costs for air conditioning, dehumidification, and heating.
3. *Buffer moderate change in RH* with 100% RAG BOARD for framing, folders, storage boxes, and drawer liners.

The following three charts are included for easy reference.

CHART 1. ENVIRONMENTAL GUIDELINES FOR DISPLAY AND STORAGE: RELATIVE HUMIDITY, TEMPERATURE, AND LIGHT

Some objects will require specific environmental conditions based on their materials, secondary components, history, and physical condition. In all cases, rapid fluctuations in RH must be avoided.

Lower temperatures are generally favorable for storage.

T, RH, and light levels should favor the most vulnerable material in composite objects and in mixed groupings. Light-sensitive objects should be kept in darkness when not on view or being studied.

Metals	Bronze and other metals	RH: 40%±5% T: 40–75°F Light: broad range acceptable
	Bronze diseased	RH: 35% or below T: 40–75°F Light: broad range acceptable
Ceramics		RH: 45%±5% T: 68–72°F Light: broad range acceptable
Glass		RH: 40–55% T: 60–75°F Light: broad range acceptable
	Crizzled glass	RH: 40–43% T: 60–75°F Light: broad range acceptable
Sculpture	Inorganic	RH: 30–65% T: 40–75°F Light: broad range acceptable
	Inorganic: polychromed/decorated	RH: 30–65% T: 40–75°F Light: 15–25fc; duration of exposure for sensitive works to be determined on a case by case basis
	Organic	RH: 50%±5% T: 68–72°F Light: 15fc; duration of exposure for sensitive works to

		be determined on a case by case basis
Arms and Armor	Organic and inorganic	RH: 50%±5% T: 68–72°F Light: broad range acceptable; for textiles, see Textiles
Ethnographic Fabrics & Fiber-based Objects		RH: 40–55%, but 50%±5% preferred T: 68–72°F Light: 3–5fc; 3–7fc for 3D objects generally limited to 3 months on view
Ethnographic Objects with a Solid Core		RH: 50%±5% T: 68–72°F Light: broad range acceptable; levels should favor the most vulnerable material in composite objects
Musical Instruments	Wood and other organics	RH: 50%±5% T: 68–72°F Light: 4fc, generally limited to 3 months per year
	Metal	RH: 35–45%, ±2% maximum fluctuation T: 68–72°F Light: broad range acceptable
Furniture	Organic	RH: 50%±5% T: 68–72°F Light: 15–20fc; 5fc or below for sensitive materials, generally limited to 3 months per year
	Synthetic	RH: 45% or below T: 68–72°F (5–10°C for storage) Light: 5–15fc, depending upon degradation
	Inorganic	RH: 45% or below T: 68–72°F Light: broad range acceptable
Upholstery		RH: 50%±5% T: 68–72°F Light: 5fc or below, limited to 3 months per year
Paintings		RH: 45–55% T: 68–72°F Light: 15–25fc; duration of exposure for sensitive works to be determined on a case by case basis

Miniatures on Ivory		RH: 50–55% T: 68–72°F Light: 4fc, limited to 3 months every two years
Asian Lacquer		RH: 50–55% T: 68–72°F Light: 5–10fc, depending upon current state of degradation; duration of exposure to be determined on a case by case basis
Ivory & Bone		RH: 45–55% T: 68–72°F Light: 15ftc or below, depending upon secondary materials; duration of exposure determined on a case by case basis
Paper		RH: 50%±5% T: 68–72°F Light: 5fc or below, limited to 3 months per year
Photographs		RH: 50% (storage 40%) T: 70°F Light: 4.0–4.8fc, generally limited to 3 months per year
Books	Library display	RH: 50%±5% T: 68–72°F Light: 5fc or below, limited to 3 months per year
Asian Paintings on Silk & Paper		RH: 50%±5% T: 68–72°F Light: 5fc for 3–6 months, or determined on a case by case basis
Textiles		RH: 50%±5% T: 68–72°F Light: 5fc or below
Costumes		RH: 40–55%, lower levels preferable; ±2% maximum fluctuation T: 68–72°F Light: 5fc or below, maximum 3 months per year

CHART 2 . ENVIRONMENTAL GUIDELINES FOR COLD STORAGE

In all cases, rapid or daily fluctuations between minimum and maximum RH and T levels are *unacceptable*.

When returning to optimal RH and T conditions after more than 24 hours at suboptimal levels, changes should occur slowly, over at least 48 hours.

RELATIVE HUMIDITY AND TEMPERATURE LEVELS FOR COLD STORAGE BY TYPE OF OBJECT

Temperature	Humidity	Types of Object
60°F (±3°F)	45% (±5%)	All glass, especially “sick” glass
60°F (± 3°F)	38% (±5%)	Magnetic media, problematic metals, and electronics/playback devices; some photographic materials, digital prints, mixed media, and objects made of or including plastics
40°F (±3°F)	40% (±5%)	Film-based materials; some photographic materials, plastic objects, and mixed media
0°F (freezing) off-site	Uncontrolled; all materials must be packaged.	Long-term storage of photographic prints and film-based materials

CHART 3. ENVIRONMENTAL FACTORS CONTRIBUTING TO THE DETERIORATION OF ARTWORKS

Environmental Factor	Chemical Reactions	Dimensional and Other Physical Changes	Biodeterioration
Excessive humidity	Corrosion and tarnishing of metals Efflorescence of salts in stone, ceramics, and glass Decomposition of cellulose and proteinaceous materials, such as paper, parchment, leather, textiles, adhesives (vegetable and animal) Fading of color dyes in photographs and transparencies Migration of impurities, and staining in organic objects	Changes in size and shape of hygroscopic materials (paper, parchment, leather, textiles, wood, ivory, reeding) due to absorption of moisture, such as swelling, expansion, warping, splitting, cracking, softening (e.g., tightening of canvas, cockling of paper) Expansion of different materials at different rates, causing damage in objects made of more than one type of material	Mold growth, mildew, fungus, dry rot Encouragement of certain types of insect activity
Excessive dryness	Embrittlement, desiccation, and shrinkage of organic materials due to dehydration (e.g., collapse of cellular structure and rupture of fibers in paper, textiles, leather)	Changes in size and shape due to dehydration (e.g., drying out of adhesives, detachment of veneers, cracking of book bindings, slackening of canvas, warping of wood)	
Excessive heat (due to high ambient temperature from radiators, sunlight, incandescent light, spotlights, photo flood lamps)	Acceleration of aging and desiccation of organic materials due to increased rate of chemical reactions	Softening of resins, waxes, gums, with consequent attraction of dust Distortion and bulging of wax-lined canvas paintings Pinpoint flaking of panel and canvas paintings	

		Splitting and warping of wood due to dehydration	
Light Visible and ultraviolet below 400nm	Photochemical and oxidative reactions such as color changes and structural breakdown in organic materials In visible light: fading of fugitive dyes; bleaching of wool and paper; color changes in some organic pigments In UV light: yellowing of silk and paper; bleaching of paper, oxidation of lacquerware surfaces; darkening of some light woods; fading of some dark woods; discoloration of some natural and synthetic resins; breakdown of cellulose and proteinaceous materials	Physical breakdown, such as embrittlement, of organic materials as a result of chemical reactions catalyzed by light	
Atmospheric pollution Sulfur dioxide Nitrogen oxides Ozone Hydrogen sulfide	Corrosion of metals, including iron, steel, and some bronze alloys Deterioration of some materials containing carbonates, such as marble, limestone, and frescoes Color reactions such as bleaching of synthetic dyes	Weakening of structure and loss of strength in materials as a consequence of chemical deterioration (e.g., loss of detail in marble and limestone statuary, loss of strength due to fiber breakdown in paper and textiles, powdering of leather)	

Soot and dust	Degradation of cellulose and proteinaceous material and many synthetics Tarnishing of silver Blackening of lead pigments such as lead white and red lead Staining in organic materials due to acid migration	Soiling and discoloration of surfaces	Encouragement of certain types of mold growth
Proximity to detrimental materials Organic acids from wooden storage cabinets Sulfur vapors from rubber-based products Wood and wood-pulp materials Skin oils and salts	Corrosion of metals such as copper alloys, bronze, lead, and zinc, sometimes in conjunction with bronze disease Colored spotting on black-and-white silver photographs Tarnishing of silver objects; staining and deterioration of cellulose materials Migration of acidity leading to weakening and discoloration (e.g., browning of paper) Etching of metals; staining of organic materials such as leather and paper	Loss of tensile strength in organic materials	Encouragement of certain types of mold growth

29. GLOSSARY

Marjorie Shelley and Rachel Mustalish

N.B. Many brand names are cited in this glossary. These are products currently in use in the Metropolitan Museum and have been tested and found acceptable for the purposes described. Commercial products are periodically updated and subject to change without notice; thus without access to scientists who can undertake testing, the reader should check these and similar products through internet sources and suppliers of these products and preservation materials to determine their safety for art-preservation procedures.

A

Acid. Acidity is one of the agents responsible for the degradation of artworks. Acids exist in solid, liquid, and gaseous form and can destructively react with the materials of which art objects are composed or constructed. Acidity will cause chemical and structural deterioration in INORGANIC materials, such as metals, by causing the development of SALTS; and in ORGANIC materials, such as paper-based objects and textiles, by provoking embrittlement and discoloration. Acidity can be inherent in artists' materials, introduced in the manufacturing process, or introduced by migration from acidic materials. To limit or remove exposure to acidic sources (such as some atmospheric gases and certain wood housings), works of art must be displayed and stored in controlled environments and with INERT or ACID-FREE materials. The unit of measurement for acidity is pH.

Acid-free. A term describing manufactured or natural materials that have a neutral pH (pH7.0) or slight alkalinity that are used in the storage, display, and wrapping of artworks. These materials have greater permanence than acidic materials, offer resistance to acids in the environment, and will not provoke acid degradation of neighboring materials. Many such materials are described as ARCHIVAL-quality. Examples are ACID-FREE PAPER OR BOARD and WHEAT STARCH PASTE. The term *acid-free* is usually applied to CELLULOSIC products, whereas SYNTHETIC products that do not provoke deterioration in other materials and are not subject to deterioration are referred to as INERT. *See* Buffer.

Acid-free board / paper / tissue. *See* Paper and paper products.

Acid migration. The transfer of acidity from one material to another that is less acidic, such as the acidity from wood migrating into a sheet of paper with which it is in contact. Usually this results in staining of the vulnerable object and severe weakening of its structure.

Acrylic adhesives. *See* Adhesives.

Acrylic sheeting. An INERT plastic made of polymethyl methacrylate (trade names PLEXIGLAS®, Perspex®, Lucite®, Optium®, and others) used for relatively light-weight transparent sheeting for picture-frame GLAZING, display cases, mounts, and ultraviolet (UV) filter sleeves for fluorescent tubes. It provides a physical and moisture BARRIER and can be coated to filter out UV LIGHT, the most damaging part of the spectrum. Acrylic

sheeting can generate a static charge; thus when used as picture-frame glazing for works with powdery or FLAKING surfaces, direct contact with the work of art must be avoided by employing a deep mat or a fillet beneath the frame rabbet. Static charge also attracts dust, thus PLASTIC SHEETING may require wiping with an ANTI-STATIC solution prior to installation. The UV-filtering capacity of acrylic sheeting may dissipate after about ten years when used on fluorescent lighting, thus it must be periodically replaced. Many types and thicknesses of acrylic sheeting are available, all of which scratch easily. Some (among them, Optium®) are coated to substantially eliminate static charge, filter out UV, and reduce reflection.

Activated carbon/charcoal. For preservation purposes, this INERT, porous, amorphous form of carbon is used as a molecular trap for atmospheric pollutants (VOLATILE ORGANIC gases such as sulfur and nitrogen dioxide) in mechanical air-handling systems. Activated carbon is used in sealed VITRINES ("art envelopes") to SCAVENGE pollutants, and is incorporated into some paperboards as a molecular trap for deleterious gases. Such boards can be used to line cases and boxes; however, they cannot be used as window mats because of their gray-colored core and tendency to smudge.

Adhesives. There are a vast number of adhesives made of natural and SYNTHETIC materials used in conservation processes and in the construction of storage and exhibition housing. The appropriate one for a project depends upon the properties of the materials to be repaired or constructed and the materials that will be in proximity to the particular adhesive. Some can emit corrosive vapors, stain, have limited durability, or are irreversible. The complex chemical nature of adhesives, their additives, drying mechanisms, and variable aging properties must be considered in the choice of an adhesive for materials in contact with works of art and should be determined by a conservator. Among the many properties to consider: that the adhesive have a nearly neutral pH (be ACID-FREE), not off-gas, is colorless, is not liable to yellow or discolor on aging, and does not cause discoloration or weakness in the material on which it is being used. It should not attract moisture or dust which can promote CORROSION or BIODETERIORATION. Among the numerous adhesives available, relatively few are used in preservation/conservation procedures. Some referred to in this manual are:

> **PVA, white glue:** Emulsions of polyvinyl acetate of variable composition that are water-soluble in liquid form but dry to an insoluble transparent film. Conservation-grade white glues (such as Jade 403®) may be used for constructing housing materials, such as storage boxes, but must not be used to repair art objects. Lower-grade white glues intended for household use age poorly, may emit harmful gases, and discolor and should not be used for storage or housing intended to protect works of art.
>
> **Wheat starch paste:** Adhesive made from highly purified wheat starch requiring soaking and cooking to activate its adhesive properties. It has good aging properties and is commonly used for HINGING and repair of paper-based works of art. Objects on which wheat paste is used require WEIGHTS while drying to avoid cockling and distortion. It is advisable to seek advice from a conservator or guidebook (see the Suggested Reading lists) for this procedure.
>
> **Acrylic adhesives** are available in a wide range of formulations for various applications in constructing display and housing structures. Some are formulated as pressure-sensitive adhesives for TAPES and films; other two-part acrylic

systems are used for structural bonding applications that require tensile and sheer strength, shock and impact resistance. The properties outlined above are required in these adhesives: that they be non-yellowing, not off-gas, have high optical clarity, and have a nearly neutral pH.

Ageless®. A product designed in several formulations to absorb oxygen from the air. These OXYGEN SCAVENGERS are composed of fine particles of iron mixed with a natural ZEOLITE and a small amount of sulfur and sea salt. This mixture is sealed in small POLYETHYLENE bags that are permeable to oxygen but not to moisture. It is usually placed with, but not touching, an infested object inside a sealed bag for ANOXIC TREATMENT.

Airborne particulates. Generally, microscopic particles from soot, smoke, and dust of all types that can remain suspended in the air for long periods, eventually settling on works of art and surrounding materials. Their chemical composition and shape can vary greatly depending upon their source, but all present hazards of physical damage, such as abrasion, and chemical and structural damage from ACIDITY. Accumulations of particulate matter can absorb moisture and provoke BIODETERIORATION.

Anoxic. In conservation and preservation practices, a treatment or environment in which oxygen in absent.

Anoxic treatment. A procedure wherein oxygen is removed from a closed chamber to eradicate many insect types, insect eggs, and larvae by asphyxiation. The treatment requires an airtight container filled with an INERT gas and SCAVENGERS to remove any oxygen that has remained or leaked into the chamber. This treatment does not utilize any chemicals that can react with objects and is a preferred method for museum pest control. Effective treatment that will destroy the insect's reproductive cycle can take up to six weeks. Among the factors that must be considered by a conservator and scientist in determining the suitability of this treatment is if the absence of oxygen may contribute to the dehydration of certain materials such as parchment and wood.

Anti-static brushes, bars, cloths, and liquid cleaners. Products used on mounting, framing, and wrapping materials, generally PLASTICS, to dissipate static charge. If these materials are not treated, static charge can endanger art objects they are meant to protect by causing tearing or structural damage (such as movement of thin papers, textiles, feathers, and fur), dislodging of powdery media (such as charcoal, pastel, chalk, underbound paints), and attracting dust and particulate matter. Anti-static brushes and deionizing bars contain charged material that help remove stray charges, but both must be grounded to be effective. Commercial anti-static liquids are effective in dissipating static charge. Anti-static solutions should be used only on protective plastic BARRIERS, such as VITRINES, never on a work of art. To use, they are applied to the cleaning cloth or TISSUE (such as KIMWIPES®) that in turn is used to wipe the mounting, frame GLAZING, or wrapping material.

Anti-tarnish paper, tarnish-resistant cloth. Paper impregnated with a sequestering agent that absorbs hydrogen sulfide from the air, thereby inhibiting tarnish formation on silver. Anti-tarnish paper is used in display cases and housing but should not come in direct contact with art objects. The use of this material should be determined by a conservator. *See* Pacific Silvercloth®; Scavengers.

Archival (archival-quality). A term used to describe products or materials that do not themselves have detrimental aging properties and that are free of chemicals that can adversely affect art and historic objects. Archival materials may be natural or SYNTHETIC and are used for display and storage purposes (for example, boxes, interleaving frame BACKINGS, wrappings, ENCAPSULATING documents). Archival paper is defined as a material that is lignin-free, sulfur-free, is alkaline-pulped, and has an alkaline reserve. Synthetic materials described as archival are INERT, chemically resistant, thermally and dimensionally stable. The suitability of the archival storage material must be evaluated for the specific work of art: for example, archival TAPE is suitable for securing packaging but potentially damaging when applied to a work on paper or a textile; BUFFERED tissue is suitable as an INTERLEAF for a drawing on paper but not for photographs. *Archival* is a nontechnical term. It is neither quantifiable nor standardized and is often indiscriminately applied; thus a product so described must be carefully assessed before use. *See* Paper and paper products: Acid-free paper and archival board.

Archival board. *See* Paper and paper products.

Archival tape. *See* Tape.

Art conservation. A broad field of professional practice dedicated to preservation through chemical and structural stabilization of artworks, archaeological and cultural artifacts and property that have sustained damage from deterioration, loss, neglect, or unsound intervention. Examination, treatment, analysis of materials and techniques, determinations of authenticity and dating, and assessing the impact of the object's environment, display, storage, or transport conditions are based on knowledge of the history and composition of materials, technological processes, and mechanisms of deterioration. Conservators undertake treatment and oversee preventative care, risk assessment, and environmental controls. Conservators usually specialize in a particular material or related group of objects, such as works on paper, books, paintings, photographs, ceramics, textiles, metals, or architectural material.

Art Sorb®. A BUFFER material used to maintain a specific humidity level or narrow range of humidity in an enclosed environment, such as a frame, display case, or MICROCLIMATE. It changes in humidity by adsorbing and desorbing moisture. It is available in the form of beads, sheets, or cassettes.

Aspirating psychrometer. *See* Humidity meters.

B

Backing material. A term designating both rigid or semi-rigid sheeting used on the backs of frames to offer physical protection (such as COROPLAST®, FOAMCORE, RAG BOARD [*see* Paper and paper products], ARCHIVAL BOARD [*see* Paper and paper products]), a MOISTURE VAPOR BARRIER (such as ACRYLIC SHEETING, MARVELSEAL®), or transparent protection (such as MYLAR®).

Barrier materials. A term describing materials used between a work of art and its mount, its housing, its transport cart, its support, or another object to prevent the risk of ACID MIGRATION into the work of art, to prevent abrasion to the work of art, or to block out LIGHT. The choice of a rigid or flexible barrier material and its textural or other

characteristics depends upon the requirements of the artwork. Depending upon the conservator's recommendation, barrier materials may be loosely secured, tied in place, or held with ADHESIVES. Examples of barrier materials are: PAPERS or paperboard, COROPLAST®, MYLAR®, NONWOVEN polyester fabric, PLASTIC SHEETING, DUST COVERS, FOAMCORE, FOAM sheeting.

Biodeterioration. The action of biological organisms, including fungus, bacteria, and insects, causing chemical and physical decay of ORGANIC and some INORGANIC materials. Visible signs of biodeterioration include but are not limited to: **Flyspecks:** Small black or dark brown accretions from excrement deposited by insects that, when left untreated, can cause staining, ACIDIC degradation, and visual disfigurement. **Frass:** Fine powdery debris in various colors resulting from the metabolic processes of wood-boring insects. Frass is an indicator of recent or past insect infestation. **Fungal staining:** The colored products caused by the biological processes of mold and other fungi that can cause chemical deterioration of an art object. **Grazing:** Shallow areas of loss (circular, or narrow and elongated) on the surface of organic works of art caused by insect activity. Often this damage is selective depending upon the nutrient constituents of the binding media, particular pigments, or adhesives. **Insect exit holes:** Sharp-edged holes visible on the surface of wood objects caused by tunneling, wormlike insect larvae. Exit holes occur when the larvae, developing from eggs deposited in the infested wood, eat through and emerge from the object. Sometimes called wood worm, this often indicates the presence of insect infestation. **Mold:** Appearing as cottony (fungal hyphae) circular deposits in almost any color, most frequently afflicting organic materials but also occurring on inorganic materials that have been exposed to as little as 48 hours of high humidity or moisture in darkness or subdued LIGHT, often in environments with noncirculating air.

Blanching, efflorescence. Terms used to describe the hazy, white, opacifying effect caused by LIGHT scattering that can appear on many objects, such as varnished and GLAZED paintings, works on paper, sculpture, WEEPING/CRIZZLED glass, leather, and PLASTICS. It is caused by diverse factors, such as water-soluble compounds in the substrate material migrating to the surface of the object; organic compounds, such as fatty acids, emanating from the binding media in paint; or the introduction of moisture or chemicals that disturb the structure of the material, thus changing its optical properties.

Blotters. *See* Paper and paper products.

Blue wool standards. Cards containing eight strips of blue-dyed wool of graduated light-sensitivity used as a standard to measure fading. They are useful in estimating the intensity of lighting in a display case or gallery for a specified period of time, and hence the damage that would be incurred to an object exhibited under those conditions. To use, the cards are placed in a gallery or exhibition case under the lighting conditions that will illuminate the work of art. Assessment of the lighting is based on the relative fading of the dyed samples. *See* Light, lighting; Light meters.

Bronze disease. A form of CORROSION found on copper and its alloys, resulting from the reaction of chloride SALTS on copper in the presence of water and oxygen. In archaeological objects, bronze disease usually results from burial in saline soils, but it may result from other sources, such as storage in ACIDIC wood cabinets, or atmospheric pollution. It is generally recognized by its green color, pitting, and deterioration of the metal.

Bubble Wrap®. A brand name commonly used to describe all air-cell CUSHIONING materials. Bubble wrap consists of fused layers of flexible, transparent PLASTIC incorporating air pockets, is usually made of POLYETHYLENE, and is damaging to works of art when placed in direct contact with them. It is generally used for cushioning and wrapping art objects in transport, but also as shelf PADDING. Bubble wrap is most effective in reducing impact shock when the bubbles face outward from the object. Bubble wrap should not come in direct contact with works of art. Objects should be first covered or separated from the PLASTIC SHEETING with INTERLEAVING material, such as ACID-FREE tissue, to guard against condensation, sticking, or marring, particularly to avoid the small dots that may be imprinted on smooth surfaces should the bubbles face inward. *See* Padding.

Buffer. A term used to describe materials (buffering agents) that are used to stabilize or regulate humidity or neutralize ACIDITY in an enclosed environment in which a work of art is contained. Examples of buffers used for maintaining specified climate conditions in MICROCLIMATES by absorbing and releasing MOISTURE VAPOR are PAPER products, salt solutions, conditioned ART SORB®, and SILICA GEL. Examples of buffers used to inactivate or neutralize the ACID MIGRATION from a more to less acidic material are ZEOLITES, ACID-FREE paper and board, and BUFFERED PAPER and board.

Buffered paper. *See* Papers and paper products; Buffer.

C

Cardboard. *See* Paper and paper products.

Carpet pads. Carpeting that is used to cushion heavy works of art in transit and storage to protect from slipping and abrasion. It is often affixed to the horizontal ledge of side trucks, where it serves to reduce vibration in transit. It should be used with caution, as the carpet loops tend to collect dust and hide debris (such as nails, staples, tacks) that can scratch objects; its fibers and RUBBER-based liners may be CORROSIVE to metals. A layer of POLYETHYLENE foam on top of the carpet may be required to protect vulnerable objects. Carpet pads are not recommended for long-term storage.

Cellulose acetate and cellulose triacetate. Frequently referred to as acetate, these generally clear PLASTIC FILMS (semi-synthetic polymers) are not sufficiently chemically stable to be used as housing or protective sheeting for art objects.

Cellulose nitrate. A semi-synthetic PLASTIC introduced and used for photographic film, molded sculpture, and as an ADHESIVE in the early twentieth century. It is highly unstable and degrades catastrophically. As it ages, it releases nitric ACID, which will cause the object to deteriorate and can destroy neighboring art objects.

Cellulosic. A material consisting of cellulose, one of the primary components of plants. It is found in all works of art derived from plants, such as paper, cotton, and linen fabrics, and synthetics derived from cellulose such as rayon and cellophane. Natural cellulosics are vulnerable to ACID degradation and damage from LIGHT.

Collections care. Encompasses the management of all aspects of a collection and PREVENTATIVE CONSERVATION. It is based on the premise of preserving works of art and reducing the need for interventive treatment by maintaining optimal environmental conditions in gallery and storage areas and in transit; appropriate handling of objects; and the use of approved, stable materials for exhibition and storage. Emergency preparedness (see Chapter 21), INTEGRATED PEST MANAGEMENT, and collections documentation are also basic practices in maintaining a collection in stable condition.

Composite woods. Also known as engineered woods, these comprise a range of derivative hard and soft wood materials, such as plywood, particle board, fiberboard, and MDF (medium-density fiberboard) and may be processed with detrimental adhesives. These materials are a source of ACIDITY to art objects, as they tend to off-gas VOLATILE ORGANIC COMPOUNDS (VOC), such as urea-formaldehyde, which can corrode ORGANIC and INORGANIC works of art and their component materials. Only composite woods tested as suitable for works of art should be used for exhibition or storage cases. *See* Woods.

Conservation science. The analysis of the materials of cultural artifacts and property by chemical, physical, biological, archeometric, and instrumental investigation. This information is used to determine the composition, state of deterioration, age, and through this means the authenticity and provenance of an object. Conservation science is employed to assess the materials used for the conservation, display, and storage of artworks, and their environmental conditions.

Coroplast®. A semi-rigid corrugated PLASTIC board composed of a copolymer of POLYPROPYLENE and POLYETHYLENE. These ARCHIVAL-quality, moisture-repellent sheets are light, strong, and INERT. Coroplast® boards are used for enclosures, frame BACKINGS, supports, and housing.

Corrosion. The deterioration and degradation of a metal in reaction to its environment. This most commonly occurs in the presence of MOISTURE VAPOR and oxygen but can also be provoked by ACIDS, bases, SALTS, oils, and other solid and liquid compounds and gaseous vapors. It is invariably accompanied by loss, deterioration, or alteration in the surface and fabric of an object, in its color or texture. It most commonly occurs in metals such as rusted iron but also in metal-containing pigments and inks, such as copper green and iron gall ink.

Cotton batting. Material used for CUSHIONING objects in transit or storage. Because cotton fibers may contribute to FLAKING of vulnerable surfaces, such as ancient glass and glazed or painted ceramics, or snag loosely attached wires or fittings, it should be wrapped prior to use in unbleached MUSLIN or NONWOVEN polyester fabric. *See* Padding.

Craquelure (crazing). A network of various patterns of cracks that forms on the surface or to a greater depth, locally or overall, on paints, varnishes, enamels, lacquers, ceramic glazes, polymers, and plastics. It may be part of the process of aging or the rate of drying of the different layers of the material, or it may be intentional from the formation or production of the material. It is often stable without a detrimental effect on the object, or it may precede fracture of the affected layer.

Crizzled. Exhibiting a network of fine cracks with a BLANCHED surface.

Cushioning material. Chemically INERT wedges, FOAMS, TISSUE paper, and other materials used to stabilize works of art for transit and storage. *See* Padding.

D

Daylight. *See* Light, lighting.

Dew point. The temperature at which the water vapor in the air condenses, forming water droplets on a surface. The dew point is dependent upon the given RELATIVE HUMIDITY (RH). The higher the RH, the more quickly the dew point will be reached as the temperature decreases. The environment must be controlled to avoid reaching the dew point, as condensation will damage most works of art.

Dial hygrometer. *See* Humidity meters.

Digital hygro-thermometer. *See* Humidity meters.

Dust covers. Dust is hygroscopic and therefore attracts moisture, which encourages mold and insects, and can be chemically and physically detrimental. Dust covers, made of fabric, PLASTIC, or PAPER, are used to protect furniture or other works of art from dust, which may not be removable from delicate or porous objects, and to block LIGHT. Dust covers should be loose-fitting, light-weight, and made of low-friction cloth, such as cotton or rayon, but the appropriate cover will depend upon the materials of the art object and should be determined by a conservator. Dust covers should not trap moisture, therefore must not be tightly sealed, and should be labeled to reduce unnecessary handling. As part of regular housekeeping procedures, they should be periodically washed.

Dust removers. Tools that are used for removing dust from glass and acrylic VITRINES, pedestals, frames, furniture, or from works of art such as smooth stone sculpture. They include FEATHER DUSTERS, lamb's wool, soft brushes, and Japanese hake brushes (which do not have metal ferrules), and synthetic dust cloths (such as Swiffers®), the latter of which are treated or have a particular fibrous structure to attract and hold dust. These tools, as well as VACUUM CLEANERS with protected nozzles, are never used to remove dust on objects that are subject to FLAKING, have porous or rough surfaces, or loosely adhered parts. Dust removers also include ethyl alcohol and proprietary glass and ANTI-STATIC liquids. In all cases, the type of dust remover and the technique, both of which must be appropriate to the object being cleaned, should be determined by a conservator.

Dusters. *See* Dust removers; Feather dusters.

E

Efflorescence. *See* Blanching.

Encapsulation. An ARCHIVAL method of protecting paper artifacts between two sheets of an INERT, POLYESTER film (MYLAR®) that are sealed (sometimes with an air space) around the edges with double-faced, flexible, nonmigrating TAPE; by heat welding; or by ultrasonic vibration. Encapsulation provides visibility, support for brittle objects, and

protection from handling and atmospheric pollutants. Because of potential deleterious compounds within the artifact that may off-gas, decisions to encapsulate such artifacts should be made by a conservator. Works of art are not encapsulated.

Erasers. Materials that can mechanically lift or remove dust and dirt from a surface without the addition of water or chemicals. Erasers must not be used on works of art. Many contain abrasives and detrimental chemicals (such as sulfur in RUBBER erasers), and improper use may cause abrasion and lifting of pigmented surfaces. Some vinyl erasers (such as Mars® plastic or Magic Rub®) and Opaline® powder erasers may be chemically safe to use on housing and mounting materials but leave a residue that must be carefully brushed away to avoid physical damage to neighboring objects and the accumulation of dust.

Esterfoam®. INERT, black, relatively soft polyurethane FOAM used for insulation and shock absorption in packing. It is not used for storage. *See* Padding.

Ethafoam®. INERT, white, rigid FOAM used for shock absorption in packing. *See* Polyethylene.

F

Feather dusters. A dusting tool made of bird feathers. While these dusters are generally not recommended for use on many art objects because of the risk of FLAKING and of snagging and dislodging loosely held components, and because they displace dust rather than remove it, they are only appropriate for certain objects, such as smooth stone sculpture, and other works where synthetic or other dusting devices are not suitable. Their use and proper technique must be determined by a conservator.

Fiber optic lighting. *See* Light, lighting.

Flaking. The separation of paint or other surface material from the substrate.

Fluorescent light. *See* Light, lighting.

Flyspecks. *See* Biodeterioration.

Foam. A synthetic polymer resin, such as POLYETHYLENE and POLYPROPYLENE, "microfoams" and "polyfoams" formed with closed or open-air cells. Compressible foams that are INERT and chemically stable, or ARCHIVAL, are used for CUSHIONING, housing, and packing art objects and to absorb shock. They are available in a range of densities, hardness, and thickness, such as soft polyethylene sheet foam (VOLARA®) for smooth, nonslip surfaces, for wrapping, storage containers, and PADDING. Rigid or semi-rigid foams of various densities made of polyethylene, such as ETHAFOAM® (white) or ESTERFOAM® (black) (which has ANTI-STATIC properties), can be cut in blocks or to the shape of the object to cushion packing crates. The density of foams used for packing objects for transport must be determined by an art-packing specialist. Foams with poor chemical properties—such as foam rubber, Styrofoam, and polyurethane foam—tend to deteriorate and should be avoided. Polypropylene foam has similar properties to polyethylene closed-cell foam. It is light-weight, low-density, chemically resistant, and

inert and available in rigid or semi-rigid forms. It is used for cushion packaging of art objects.

Foamcore, foam board. A strong, light-weight, and easily cut material in various thicknesses used for preservation purposes as a BARRIER MATERIAL or separator, a frame BACKING, and as a supporting layer for light-weight planar objects. It consists of an inner layer of polystyrene clad with outer facings of white clay-coated paper and/or KRAFT PAPER. Most foamcore is ACIDIC and not suitable for ARCHIVAL purposes; however, an ACID-FREE, BUFFERED version is available that may not off-gas. *See* Paper and paper products.

Foot-candle. A unit of measurement for illuminance, indicating the amount of LIGHT cast over a specified area from any light source (natural, incandescent, fluorescent, halogen). The term is derived from the amount of light cast by one candle at a distance of one foot. The metric equivalent is lux. Approximately one foot-candle equals ten lux.

Foxing. Reddish brown spots or stains on and within paper, many paper products, and textiles caused by fungus, a biological organism flourishing under conditions of ACIDITY and high humidity, both in darkness and in light. Fox marks are also the result of iron inclusions deposited during the papermaking process from metal machinery that under conditions of high humidity and acidity alter in chemical state, becoming reddish brown.

Frass. *See* Biodeterioration.

Freezing. A method of eradicating fungal and insect infestation in a work of art based on prolonged exposure to low temperatures. Because of the profound damage freezing can provoke in ORGANIC works of art, the materials and structure of the object must be assessed by a conservator, and the treatment must be undertaken by experienced personnel in a cold-temperature eradication facility. Freezing is also used as a disaster response method to dry waterlogged books when immediate conservation treatment must be postponed. This treatment requires professional equipment.

Fumigation. Traditional methods employing PESTICIDES and toxic gases are no longer considered appropriate in the museum environment because of the dangers posed to humans and the chemical changes they provoke in works of art. *See* Anoxic treatment.

Fungal staining. *See* Biodeterioration.

G

Glass. Used for framing works of art with powdery surfaces that are at risk of damage from the STATIC CHARGE generated by ACRYLIC SHEETING. Standard glass is clear and scratch-proof, but can be heavy and breakable, and does not filter ultraviolet (UV) LIGHT. Glass can be modified by coating or layering treatments to reduce its reflectivity and filter out UV light, and tempered so that it crumbles instead of shatters when broken. UV shatterproof glass is made of two sheets of glass laminated with a polymer resin, thus reducing the amount of damaging scattered shards if the glass is broken. This type of glass is highly transparent, antireflective, offers UV protection, and is used for framing delicate or friable surfaces such as pastel (brand names include Schott® and TruVue®). “Antique” glass is generally characterized by waves and bubbles or seeds, and may be

aesthetically desirable but is often more brittle than modern glass and thus should be handled with extreme care.

Glassine. *See* Paper and paper products.

Glazing. A term used for GLASS or ACRYLIC SHEETING for VITRINES or picture frames. A wide variety of each of these materials is used to protect museum objects from physical danger and LIGHT damage.

Gloves. The decision to use gloved rather than clean, bare hands depends upon the condition of the object and its materials. Bare hands should never touch metals, photographic surfaces, lacquer, gilded frames, unglazed ceramics, certain types of modern papers, and other materials as indicated by a specialist conservator. Soiled gloves should never be worn when handling art objects. **Cotton gloves** should not be used when handling materials that FLAKE, such as ancient glass, or with intricately worked surfaces because the fibers can snag or dislodge elements, nor used with smooth objects because they do not allow for a firm grip. Cotton gloves are generally not tight-fitting, thus do not allow for delicate manipulation. Cotton gloves with PLASTIC treads/grips may be used, but RUBBER treads must be avoided because they contain damaging sulfur. **NITRILE gloves**, a latex-free synthetic rubber, are suitable for handling many types of objects, as they provide a slip-free grip. Nitrile has good chemical and solvent resistance, high flexibility, good puncture resistance, and low friction, making the gloves easy to put on. Unpowdered nitrile gloves should be used to avoid contaminating objects after the gloves are removed. **LATEX (natural rubber) gloves** are strong and flexible but should not be used with sulfur-sensitive materials such as metals. They may cause an allergic reaction in some individuals.

Glue traps. Paper boxes with adhesive interiors, thus often referred to as sticky traps, which are placed in locations where objects are stored and examined and in work areas. They are an essential component of an INTEGRATED PEST MANAGEMENT system and serve to monitor insect and rodent populations. The trapped insects are identified and quantified by a specialist, allowing assessments to be made as to the appropriate procedure for their eradication. Pheromone (insect attractants) glue traps are often used in locations containing art; however, to avoid attracting insects, only pheromone-free traps should be placed near museum entrances and loading docks. Toxic substances are not used in these traps, thus they do not present health risks to personnel and damage to works of art. A useful site on glue traps is www.insectslimited.com.

Grazing. *See* Biodeterioration.

Gummed cloth tape. *See* Tape.

H

Halogen lighting. *See* Light, lighting.

HEPA filter. High-Efficiency Particulate Air filters, or HEPA units, may be incorporated into the filtration system of a building, or that of a VACUUM CLEANER. HEPA filters can remove a substantial percentage of AIRBORNE particles of minute dimensions from 0.3 micrometers (µm). These include small particulates such as mold spores, pollen, dust,

and mite feces that are usually not trapped by standard filters or vacuums, and thus a HEPA filter is effective for areas where art objects are treated or stored.

Hinging. The means of securing a work on paper or related material to an ACID-FREE backboard with two or more relatively small pieces of flexible, folded paper for safe display, study, storage, and handling. Long-fibered Japanese TISSUE of thickness that is suitable to the thickness of the object, and WHEAT STARCH PASTE are the preferred materials for hinging. The hinging procedure can be complicated and should be determined by a conservator. Incorrect hinging can stain, tear, or cause planar distortions in the work of art. Works on paper should never be adhered directly to a backboard.

Hollytex®. A white, NONWOVEN, POLYESTER, continuous-filament fabric used for storage and preservation purposes. It has high-tensile strength, is smooth, lint-free, and light-weight, and does not contain binders or pigments. It has high static properties and thus can cling to paper, which can be a desirable property for some housing formats. It does not absorb water and, like most polyesters, can be thermally or ultrasonically welded. Similar products are Reemay® and PELLON®.

Humidity indicator cards. *See* Humidity meters.

Humidity meters/monitoring. Devices for measuring RELATIVE HUMIDITY (RH) and absolute humidity of an environment. The precision of the methods vary and should be calibrated on a regular basis to ensure accurate measurements. **Dial hygrometer:** A small humidity-sensitive instrument, about 1–3 inches in diameter, useful for display cases or other closed areas. **Digital hygro-thermometer** (digital humidity monitors): These data-loggers record temperature and RH information that can be downloaded to a computer. Small portable handheld data-loggers are useful for travel crates or spot checks of ambient environmental conditions, some having a screen, or providing data readings but without recording capacity. Units are available with LIGHT-monitoring devices, making them ideal for temporary gallery and storage spaces. **Humidity indicator cards:** A paper card impregnated with cobalt salts on a scale divided into units of 10%. The salts change color depending upon relative humidity, from darker blue at lower levels to pink with an increase in humidity. These small cards are useful in tight spaces, frame BACKINGS, and exhibition cases. Accuracy may be impaired at high temperatures, as the humidity indicated may be lower than actual conditions, and if the card is exposed to long periods of high humidity. **Recording hygrothermograph and hydrograph:** An instrument using a moisture-sensitive element, such as a hair strand, attached to a pen to record over a period of hours or weeks a continuous, time-related graph of RH. These instruments usually work in conjunction with a temperature-sensitive element, such as a metal coil, and should be recalibrated every four to six weeks with a wet and dry bulb hygrometer. **Wet and dry bulb hydrometer** (sling psychrometer, aspirating psychrometer): An instrument used for accurate measurement of RH and to calibrate other humidity meters. It consists of two thermometers, one wrapped in a MUSLIN sleeve that is dampened with deionized water. A sling psychrometer is whirled around to encourage evaporation of the wet sleeve. In an aspirating psychrometer the thermometers are mounted with a motorized fan to evaporate the water from the muslin. The measurement of RH is based on the difference in temperature between the dry bulb (which gives room temperature) and the wet bulb (showing the cooling effect of evaporation), which is determined by referring to a chart.

HVAC. The acronym for heating, ventilating, and air conditioning. HVAC systems are essential to maintaining an optimal environment that allows for only gradual variations in RELATIVE HUMIDITY (RH) and temperature levels. Museum HVAC systems provide controlled air flow, temperature, and humidity and filter AIRBORNE pollutants. HVAC systems depend on monitoring devices (such as thermostats) to sense ambient conditions, and to adjust heat, fans, coolers, and humidifiers in order to maintain preset temperature and RH levels in a gallery, work, or storage area.

I

Impregnated cloth. *See* Spray cleaners and impregnated cloths.

Incandescent light. *See* Light, lighting.

Inert. The term used in conservation and preservation practices to describe materials—such as the POLYESTER products ETHAFOAM® and PELLON®—that are chemically resistant, thermally and dimensionally stable, and do not provoke degradation in other objects or undergo a deterioration process themselves, and thus are generally suitable for use with works of art.

Infrared (IR). *See* Light, lighting.

Inherent vice. The term describing deterioration resulting from the inherent chemical composition of the material of which the object is fully or partially composed. The speed at which deterioration takes place is dependent upon the object's composition and its environment. While inherent vice can be slowed by environmental controls, it is often autocatalytic and very destructive, for example, CORROSION from iron gall ink and copper green pigments, CRIZZLED glass, and degradation of CELLULOSE NITRATE film.

Ink markers. Felt-tipped pens, permanent pens, and laundry markers should not be used on or near art objects, packing materials, and labels. The ink can migrate through layers of paper and fabric, and "sublime," whereby the ink vaporizes and the colorant settles on an object above it. These inks readily rub off, and thus transfer by handling or by direct contact with other objects.

Inorganic objects. A class of art objects and materials whose constituents, natural or synthetic, do not contain the elements carbon or hydrogen. Objects in this broad category are derived from minerals, not animals or plants. Examples are GLASS, stone, metal, ceramics, and certain pigments. Inorganic and ORGANIC art objects, each comprising a large and diverse group, undergo different deterioration processes and require different environmental conditions for their preservation.

Insect damage, infestation. *See* Biodeterioration.

Insect exit holes. *See* Biodeterioration.

Integrated Pest Management (IPM). A protocol for minimizing the threat of BIODETERIORATION to a collection and for safeguarding the museum environment (display cases, galleries, storage, work areas), by integrating the expertise and skills of conservators, biologists, scientists, curators, engineers, collections managers,

technicians, security guards, and building maintenance personnel. IPM has a three-pronged approached: (1) *Prevention.* This includes, for example, vigilance among all staff in recognizing insect activity: by maintaining a clean environment through thorough housekeeping of storage areas and galleries; thorough examination of incoming objects; climate control; eliminating moisture in walls; and establishing protocols for dealing with infested objects. (2) *Monitoring and identifying pests.* All pests do not pose the same threat to art objects, thus knowledge of life cycles can determine the best means to control a pest and to avoid unnecessary intervention by the use of GLUE TRAPS. (3) *Eradication.* Entails the use of nontoxic chemical (biological) trapping devices based on pheromones, and nonchemical treatment, such as FREEZING, ANOXIC TREATMENT, and, when required, PESTICIDES.

Interleaf. A material placed in direct contact with a work of art to separate it from another surface that is potentially detrimental because of its ACIDITY, which may migrate and damage the less acidic material, or because of media or colorants that may offset onto the adjacent surface. Interleaving should be clean, devoid of creases, nonabrasive, and ACID-FREE. Examples of interleaving material are thin, ACID-FREE PAPER or TISSUE, thin JAPANESE PAPER, RAG BOARD, NONWOVEN FABRICS, MYLAR®, or other material as determined by a conservator.

J

Japanese paper. *See* Paper and paper products.

K

KimWipes®. A lightly abrasive, slightly fibrous thin TISSUE made of virgin pulp, used with or without cleaning agents or moisture to clean GLASS, ACRYLIC SHEETING, mounts, laboratory glassware, and tools. It is also used as a temporary BARRIER when handling a work of art or its housing, and for temporary CUSHIONING. KimWipes® are slightly ACIDIC, thus should not remain in prolonged contact with vulnerable works of art, such as paper-based materials or textiles.

Kraft paper. *See* Paper and paper products.

L

Laid-down. A term describing a work on paper that has been adhered overall on its VERSO to a mount with paste, glue, or dry-mount tissue. This mounting may have been done by the artist, may be part of the object's history, or may have been done at a later date for framing, storage, or conservation purposes. Objects mounted in this manner should be brought to the attention of a conservator to determine the best course of preservation.

Latex. A natural RUBBER product/polymer used for many purposes, including the manufacture of GLOVES, house paint, sheeting, and tubing. Because processed (vulcanized) rubber contains sulfur, latex gloves and other rubber products must not be used for storage or handling of artworks, in particular objects made of metal. Allergies to

the proteins in latex also preclude their use by some individuals. Nonlatex alternatives include NITRILE, vinyl, and neoprene.

LED (light-emitting diode). *See* Light, lighting.

Light, lighting. Different types of light sources (daylight, fluorescent, incandescent, etc.) emit varying amounts or combinations of visible light, ultraviolet (UV) and infrared (IR) radiation, accounting for their particular temperatures, intensities, and colors. All bands of the light spectrum can cause damage, and thus must be controlled. To protect vulnerable materials, light should be maintained at low levels and for limited time periods; UV light should be filtered out with UV film or UV ACRYLIC SHEETING, natural light reduced with shades, curtains, or window film, and vulnerable objects kept at a distance from the light source to protect from heat build-up. Light levels should be monitored with LIGHT METERS. (See Chapter 28, Chart 1.)

Daylight. Daylight, or visible light, emits the greatest amount of UV radiation, and is often of high intensity. To filter out up to 98% of this dangerous portion of the spectrum, UV-filtering glass or tinted or untinted films must be used on windows in galleries, storage areas, or corridors illuminated by daylight. In galleries with windows, light-blocking shades should be used to reduce the amount of light impinging upon works of art. Objects illuminated by daylight should be protected from heat buildup.

Fiber optic lighting. Incandescent light in which the source is separated from the output by a bundle of fiber optic glass. This allows for relatively cool lighting that is suitable for use inside display cases because it does not generate heat.

Fluorescent light. Lighting that emits high levels of UV radiation but negligible amounts of heat. It should not be used to illuminate works of art. Because of its high efficiency, it is often used in storerooms, but it must be filtered with UV-filtering sleeves that should be replaced about every ten years.

Halogen lighting. Long-lasting, energy-efficient, bright white tungsten incandescent lighting containing a small amount of halogen, such as bromine or iodine. These lights can be hazardous to works of art: they are extremely hot, thus must be shielded and placed at a great distance from objects or any surface that can heat up, and must be coated or have a UV-absorbing filter over or around the bulb to block the emission of damaging shortwave radiation.

Incandescent light. A heat-generating light source that emits low levels of UV radiation. This light source should be at a sufficient distance from the work of art, and not used in display cases to avoid the danger of heat buildup on objects. A UV filter (such as UV ACRYLIC SHEETING) should be used when incandescent light illuminates vulnerable materials.

Infrared (IR). Infrared illumination comprises a band of the light spectrum that is invisible to the eye yet can be damaging to art because it generates heat that can accelerate aging and thus degrade many materials. IR light is not used for preservation purposes.

LED (light-emitting diode). Energy-efficient lighting that emits low heat and is UV-free. It is useful for illuminating works of art that are heat- and light-sensitive. LEDs render color differently than halogen lights, thus care must be taken in selecting the appropriate LED to prevent visual color alteration in the work of art, wall color, or display fabric. LED lighting is useful for public spaces and workrooms in which color rendering may not be critical.

Ultraviolet (UV) light. A portion of the electromagnetic spectrum that is invisible to the human eye yet the most damaging to art objects owing to its high energy, which will catalyze deleterious reactions. The greatest amount of UV is emitted in daylight, fluorescent lighting, UV-filtering glass, and halogen lighting but can be substantially filtered with UV ACRYLIC SHEETING and films, which are placed on frame GLAZING, VITRINES, windows, fluorescent tubes, and other lighting fixtures.

Light dosimeters. Like BLUE WOOL STANDARDS, these light-sensitive strips (such as LightCheck®) are for use in show cases and galleries. These tools for measuring light exposure are calibrated for their response to the visible portion of the LIGHT spectrum. They are a means of estimating the amount of light that has fallen on works on paper and textiles, and the potential for fading and deterioration. *See* Light meters.

Light meters. Instruments equipped with a photocell receptor that measure the intensity of VISIBLE LIGHT falling on an object. To take the measurement, the meter is placed approximately 4–6 inches from the work of art. The unit of measurement is the FOOT-CANDLE, or the metric equivalent referred to as lux (1 lux = 10 foot-candles). UV meters measure the quantity of ULTRAVIOLET radiation in the illuminated area, designated as milliwatts/lumen.

Lux. *See* Foot-candle.

M

MarvelSeal®. Flexible BARRIER sheeting that resists the transmission of water vapor and other atmospheric gases. It is used to create controlled MICROCLIMATES, sealed frame packages, and shipping and storage bags, as a means of preventing off-gassing from exposed wood surfaces when used as an interior lining for shipping crates, exhibition cases, and shelves, and to create a sealed environment for treating INSECT INFESTATION. It is available in several conservation grades and is readily cut to size: MarvelSeal 470® is an aluminized POLYETHYLENE and POLYPROPYLENE film and is attached by heat sealing or with PVA ADHESIVE; MarvelSeal 360® is aluminized polyethylene and nylon and attached with double-faced TAPE. MarvelSeal 1311® is a vapor barrier consisting of a PE/foil/PE laminate with a polycotton-scrim facing that allows easy attachment to wood crates or shelving with wood glue or other adhesives. *See* Moisture and gaseous vapor barriers.

Masonite®. A WOOD fiberboard invented in the early twentieth century as a cheap wood substitute. As with most wood products, it is highly ACIDIC and should not be used with art objects. It is, however, often found as a component of artworks. *See* Composite woods.

Microclimate. A sealed, relatively small environment (such as an exhibition case, storage box, or frame) for the display, storage, or transport of an ORGANIC or INORGANIC work of art, in which a designated level of RELATIVE HUMIDITY (RH) is maintained despite changes in the ambient atmosphere. A microclimate safeguards an object by providing an environment suited to the object's materials and condition and isolates it from surrounding conditions, thus can be more energy-efficient than controlling an entire gallery or storage area. Microclimates are constructed with MOISTURE VAPOR BARRIERS to prevent the transfer of air. They may contain BUFFERING agents, such as conditioned ART SORB® or SILICA GEL, to achieve the desired RH level, which may be monitored with HUMIDITY METERS placed within the case. A microclimate may also contain SCAVENGERS or paperboard with ZEOLITES. The materials from which a microclimate is constructed must be INERT; yet to guard against the buildup of VOLATILE ORGANIC COMPOUNDS (VOCs), microclimates should be periodically opened.

Moisture and gaseous vapor barriers. Materials and products used for sealing exhibition cases, storage units, and frames for MICROCLIMATES by creating a BARRIER to moisture and gaseous vapors. Such barriers are also used for sealing potentially damaging exhibition materials such as plywood and chipboard, to seal PLASTIC BAGS for storage, and for ANOXIC TREATMENT. MARVELSEAL® is frequently used for this purpose. For a moisture barrier to be effective, the corners or sites where surfaces join must be tightly sealed, often requiring pressure-sensitive TAPE, including frame sealing tape. Frame sealing tape is foil-backed, ACID-FREE paper with pressure-sensitive acrylic ADHESIVE, used to seal frame BACKING MATERIAL and as a barrier on wood frame rabbets. MYLAR® and ACRYLIC SHEETING are impermeable to moisture and will offer some but not complete protection as vapor barriers, and thus are useful when a moderate transfer of air is deemed desirable.

Muslin. A plain woven cotton fabric that, when unbleached, is used for conservation procedures, including handling and storage of certain types of objects, or as slings for transport. Before use, muslin should be washed to remove residues from the manufacturing process. Bleached muslin may have residual chemicals that can damage works of art and should not be used.

Mylar®. An INERT, transparent, thermoplastic POLYESTER film made of POLYETHYLENE terephthalate with high chemical and dimensional stability. It is impermeable to liquid water but is not completely effective as a MOISTURE OR GAS VAPOR BARRIER. Clear, colorless ARCHIVAL-grade Mylar® (Melinex® in the UK and Europe) is available in various thicknesses, and used in preservation practices for covering art objects in storage, as a protective transparent covering for mat windows, for housing works of art and books, and for ENCAPSULATING documents. Because of its STATIC CHARGE, it can attract dust, thus care must be taken to avoid direct contact with works of art if this is a risk factor. Depending upon the application, polyester film may be sealed; however, with an abrupt drop in temperature and the development of condensation, sealed Mylar® may create an unfavorable microclimate. (Mylar D® is no longer manufactured.) *See* Plastic film.

N

Nalgene Clean Sheets®. High-density, closed-cell POLYETHYLENE foam sheeting with a soft yet firm, nonabsorbent, nonwetting, smooth surface. It is used to CUSHION objects and as a tray, a bench liner for examining works of art, and a shelf liner for works in

storage. It has excellent chemical and thermal resistance and is readily cut to size. Nalgene Clean Sheets® are nontoxic and considered safe for use, as it is no longer made with BPA (bisphenol Ai).

Natural light. *See* Light, lighting: Daylight.

Newsprint. *See* Paper and paper products.

Nilfisk®. A brand name for a VACUUM CLEANER used for preservation purposes, such as collections cleaning, and for removal of hazardous particles and mildew spores. It can be fitted with a HEPA FILTER, and a rheostat to control the strength of the suction. The nozzle of the hose is generally covered with mesh or gauze by the preservation operator to prevent damage to the surface being cleaned. A comparable product is the Consevac 777®.

Nitrile. A LATEX-free synthetic RUBBER (polybutadiene acrylonitrile), most often used in preservation for disposable GLOVES, with good chemical resistance, good flexibility, and more puncture resistance than natural rubber. Because this material does not contain latex proteins, nitrile gloves are allergy-resistant. The low friction of nitrile gloves makes them easy to put on; however, cornstarch is often added for this purpose and such powdered gloves should not be used with the work of art, as residue remaining on the hands may contaminate objects that are subsequently handled.

Nonwoven fabrics. INERT, synthetic fiber fabrics, such as POLYESTER, used for preservation and conservation purposes, that are made by felting continuous filaments that are bonded by thermal, chemical, or adhesive processes. The arrangement of the fibers and the thickness of the fabric determine the individual product characteristics, which in turn determine the appropriate material for a given procedure. Generally polyester fabrics are dimensionally stable, strong when wet, resistant to chemicals and abrasion, smooth surfaced, water permeable, and inert. Nonwoven fabrics used for preservation purposes are HOLLYTEX®, Reemay®, PELLON®, PeCap®, and TYVEK®.

O

Obomodulan. Inert, polyurethane based material, available in various densities, used for boards and custom shaped mounts.

Oddy test, modified Oddy test. A testing procedure originally developed in 1973 by Andrew Oddy, former Keeper of Conservation, British Museum. The test determines the corrosive effect of vapors released by storage and display materials to be used with works of art. The test is carried out on all fabrics, PADDING materials, ADHESIVES, paints, and construction materials that are considered for use. Only those materials that do not cause CORROSIVE reactions, and thus pass the Oddy test, are acceptable. Oddy-testing of materials is especially important for works displayed in enclosed environments such as VITRINES, storage boxes, or sealed frames because harmful vapors that will degrade works of art can be trapped within such spaces. Testing requires about three weeks to confirm. Because commercial products are subject to changes in formulation without notice, periodic testing is required to determine their acceptability. Product information should always be consulted when using proprietary materials, as their formulations are liable to change.

Organic objects. A description of a class of objects or constituents (e.g., colorants, adhesives, etc.) made from materials based on the elements carbon and hydrogen. They are derived from natural biological sources: for example, PROTEINS if derived from animal material or CELLULOSE from plant matter, or their remains (such as amber), or from nonbiological sources (synthetics, such as PLASTICS or dyes). Examples of organic materials are paper, leather, bone, feathers, POLYETHYLENE, natural dyes, certain pigments, and silk and cotton fabrics. Organic and INORGANIC art objects, each comprising a large and diverse group, undergo different deterioration processes and require particular environmental conditions for their preservation.

Oxygen scavengers Substances contained in small sachets or cloths that actively remove oxygen, a highly reactive gas, from an environment such as a case or airtight bag by adsorption, absorption, or chemical reaction. SCAVENGERS (such as AGELESS®, finely divided iron particles, and potassium chloride) are used to inhibit the CORROSION of metal objects, and in ANOXIC TREATMENT to remove oxygen as part of the insect extermination process.

P

Pacific Silvercloth®. A commercially available silver tarnish–resistant storage cloth that is a SCAVENGER for sulfurous gases. The scavengers are minute particles of silver contained in the soft woven fabric that inhibit the formation of silver tarnish on the object by preferentially absorbing the detrimental gases. Tarnish-resistant cloth and ANTI-TARNISH PAPER are used in display cases and housing, but not in direct contact with works of art. The use of these materials should be determined by a conservator.

Padding, cushioning. Padding is used to reduce vibration and absorb shock during handling, shipping, and storage of artworks, or to reduce pressure on the entire object or fragile or damaged elements, and to serve as a support to prevent movement in storage or transport. Cushioning materials may be folded and layered ("wadded") ACID-FREE tissue and paper, ARCHIVAL foam sheeting (such as NALGENE CLEAN SHEETS ® and VOLARA®), BUBBLE WRAP, wrapped COTTON BATTING, FOAM blocks or wedges (ETHAFOAM®) shaped or cut to suit the object, padded baskets, folded POLYESTER fabric, blankets, sandbags, bags with glass beads, and other materials, but all should be nonabrasive, INERT, not contain loose fibers that can snag, and not generate STATIC CHARGE. Materials for padding works of art are determined on the basis of the object's textural characteristics, weight, and conformation, and should be chosen in consultation with a conservator.

Paper and paper products. Materials for wrapping works of art for storage and transport, for supporting or PADDING, and for housing or INTERLEAVING works of art on paper and textiles. The following are examples of commonly used materials:

> **Acid-free paper, archival (corrugated card) board**. Paper and paperboard products in various weights and thicknesses made from wood pulp that has been chemically processed to remove the highly ACIDIC-forming components, or from high-quality rag and cotton pulp. ACID-FREE papers may be buffered or unbuffered and have a pH of 7 or higher.

Blotters. Paper that readily absorbs moisture because it lacks sizing. Because of their nonabrasive, relatively soft surface and white color, they provide an excellent work surface and temporary protective covering for paper and textiles. Only clean, acid-free blotting papers should come in contact with works of art.

Buffered paper and rag board contain calcium carbonate or another alkaline compound (raising the pH to 8), thereby more effectively neutralizing ACIDS in the immediate environment than papers that do not contain an alkaline reserve.

Cardboard, foamcore, rag board. These semi-rigid paper and paper products are used in storage, housing, and transport to support, cover, and separate works of art and as frame BACKINGS. Unless they are acid-free, such materials should not be placed in direct contact with works of art.

Glassine. A thin, smooth, translucent wood-pulp paper commonly used as an interleaf for works on paper with stable surfaces, and for temporary wrapping of other types of objects. Only ARCHIVAL, pH-neutral glassine should be used in contact with works of art. Powdery media can offset onto glassine, thus it must be used with caution on these materials. The translucency of glassine provides visibility while protecting objects, but its sharp edges can scratch works of art, including a varnished oil painting; thus a sheet of glassine must be lifted at its opposite sides, not slid across a surface when removed or placed on a work of art. Creases in glassine can abrade art objects, thus wrinkled and torn sheets should be replaced. Yellowed and browned glassine, which is often encountered in long-stored prints and drawings, is acidic and should be replaced. ADHESIVE-backed glassine tape tends to be acidic and can stain works on paper, and should not be used for HINGING.

Japanese paper. Long-fibered, hand- and machine-made papers of varying types and qualities made of kozo, gampi, and mizumata plants used for works of art and customarily for repairing and hinging prints and drawings. The misnomer “rice paper” is sometimes used to describe this material.

Kraft paper, newsprint. Chemically and mechanically processed wood-pulp papers that are useful as a temporary outer wrapping or to cover work surfaces during framing and mounting. Kraft paper is dark brown and opaque and therefore can be used as temporary protection from LIGHT and dust while works are awaiting examination or installation, for covering objects or framed works in storage, or objects that have an intermediary protective BARRIER. Newsprint and Kraft paper are highly acidic and should not come into direct contact with works on paper, textiles, or ORGANIC objects. Only unprinted newsprint should be used for PADDING or for covering work surfaces.

Non-acid-free paper and cardboard (such as ground wood-pulp paper, strawboard, etc.) will discolor and deteriorate, and their components will stain and embrittle the materials with which they are in contact.

Permalife® is a type of archival paper that is composed of cotton and pure CELLULOSE, is acid-free and lignin-free, and buffered. For art-preservation purposes, buffered paper is used for interleaving, archival storage, lining of

drawers and cabinets, and wrapping. It is not suitable for photographs or archival photocopies.

Photo-Tex®. A brand name for a soft, all-cotton, unbuffered, sulfur-free tissue or paper. It is often used for interleaving, storage, and wrapping photographs, textiles, leather, silk, and paper objects. Renaissance paper® is also a machine-made, unbuffered paper with good archival qualities. It can be used for housing and storage.

Rag paper, rag board. Papers made from 100% cotton rag (or linen and cotton pulp) of very high quality with little acidity and good long-term aging properties. It is available buffered, unbuffered, and with ZEOLITES. It is used where permanence and durability are important, such as in matting, storage boxes, and book cradles, and as a barrier between art objects and detrimental material. Sheets of this semi-rigid material can be laminated to increase its thickness and resiliency.

Tissue. A term describing thin, often translucent Japanese or Western paper that may have a polished or matte surface. It is composed of paper pulp of varying material and quality. Only good-quality, acid-free tissue should be used for interleaving, wrapping, padding, or storage so as to avoid damage from long-term contact with the work of art.

Unbuffered paper and rag board are acid-free and pH-neutral. They are able to absorb some gaseous pollutants from the environment but can become acidic more rapidly than buffered papers over time if such vapors are present in the atmosphere. It is used for storage of photographs (cyanotypes, albumen prints, and color photographs) and objects made of leather, silk, and wool, which may be harmed by a buffering agent. Increased protection against acidity is achieved in paper and board by the manufacturer's addition of zeolites, which can absorb VOLATILE COMPOUNDS, but as these can be damaging to some works of art, consultation with a conservator is advisable. *See* Photo-Tex®.

Wax paper. A paper coated on both sides with a wax. It is used in water and flood emergencies to prevent wet items from sticking to each other and thus is recommended as an emergency supply.

Patina. The term used to describe the surface coloration of an object. Apart from patination intentionally applied by an artist or craftsman, in conservation it is associated with the physical alteration of a metal surface resulting from the chemical reaction between the metal and environmental factors (for example, oxygen, water, sulfur, and chlorine). The formation of patina can also be influenced by the object's use, handling, and mechanical and chemical surface treatments.

Pellon®. A variety of NONWOVEN FABRIC used for CUSHIONING, storage, and other preservation and conservation purposes. Pellon® is made of many different types of synthetic polymers (polyester, nylon, or rayon) with or without fillers and adhesives, but only undyed, 100% POLYESTER should be used with art objects.

Permalife®. *See* Paper and paper products.

Pesticides. Chemicals used to exterminate insects or fungi may pose long-term hazards to persons and art objects owing to direct contact or their toxic vapors, and thus are no longer considered safe for use. Pesticides (liquids, aerosols, or powders) should be avoided on museum objects and in storage areas. The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) toxicity references should be consulted before any pesticide is used. Residues of arsenic, once used to prevent INSECT INFESTATION in ethnographic materials such as feathers, furs, and skins, may remain in these objects, and thus nitrile GLOVES should be used when they are handled. Objects treated with arsenic are often identified with a green dot. *See* Anoxic treatment.

Photographic Activity Test (P.A.T.; ISO Standard 14523). An Image Permanence Institute test to determine the detrimental effects, if any, of storage and housing materials on photographs.

Photo-oxidation. The chemical and physical breakdown of ORGANIC materials and polymers due to the effect of LIGHT, or radiant energy, generally in the ultraviolet (UV) range of the spectrum. In works of art, deterioration from excessive exposure to light is indicated by fading and color alteration, structural embrittlement, and breakdown of adhesives. Under high temperature conditions, the rate and severity of photo-oxidation is increased.

Photo-Tex®. *See* Paper and paper products.

Plastic. A generic name for a wide variety of synthetic polymers that can be made into hard, clear sheets and molded shapes, flexible films, and flexible and rigid FOAMS. For preservation purposes, such materials are used for storage and housing. The type of polymer from which these materials are made is crucial to their use with art objects; some are INERT and safe to use, others have chemical components that have poor aging properties and can cause severe damage. For example, POLYETHYLENE and POLYPROPYLENE are recommended materials; polyvinyl chloride (PVC) and CELLULOSE ACETATE are not safe to use because they emit damaging volatile ACIDS and will provoke deterioration of artwork.

Plastic bags. Transparent or opaque POLYETHYLENE or POLYPROPYLENE bags that are used, when appropriate, for temporary storage of ORGANIC and INORGANIC works of art. Because of the possibility of condensation and off-gassing, sealed bags should not be used for long-term storage, or should be pierced to prevent the build-up of VOLATILE COMPOUNDS. Objects contained in sealed plastic bags should be protected with a moisture-buffering material such as ACID-FREE tissue or a dry SILICA GEL packet.

Plastic film. Thin, flexible sheets of various types of synthetic polymers that are used as moisture and protective BARRIERS in storage and for packing art objects. Because of their STATIC CHARGE, they must not come in direct contact with vulnerable works of art, which should be protected with a layer of TISSUE paper or GLASSINE. Despite the similar appearance of many plastic films, their chemical composition can be vastly different, and some may be severely detrimental. *See* Mylar®.

Plastic sheeting. INERT plastic sheeting made of POLYESTER, POLYPROPYLENE, or POLYETHYLENE that is useful as a protective moisture BARRIER or outer wrapping for covering objects or placing between a work of art and a detrimental material. The

sheeting should be loosely wrapped around the object or separated from it with TISSUE, RAG BOARD, or MUSLIN to guard against condensation, and adhering or marring its surface. Plastic attracts dust, therefore the side toward the work of art must be clean. Objects covered with plastic sheeting should be periodically checked. Care must be taken in removing plastic sheeting to prevent damage to the object. Plastic sheeting should be included in emergency preparation kits (see Chapter 21), as it is essential for covering objects.

Plexiglas® (Perspex® in the UK and Europe), Lucite®, Optium®. Brand names, among others, of transparent, thermoplastic ACRYLIC SHEETING used for picture GLAZING, display cases, and mounts. *Plexi* is used as a generic term for this type of material; however, each manufacturer has several grades, and each brand has different properties, thus the particular application must be considered in choosing the appropriate one for preservation purposes.

Polyethylene. This most widely used PLASTIC is classified into several different categories based on its manufacture and density, the physical property that determines how it is used for preservation purposes. Most grades of this versatile resin have excellent chemical resistance (including that it is not biodegradable). It is used for rigid plastic containers, flexible bags and sheeting, transparent film, FOAM sheeting such as VOLARA® and TYVEK®, and rigid foams such as ETHAFOAM®.

Polyester. A type of synthetic polymer (PLASTIC) considered sufficiently INERT to be used for preservation purposes as supporting material or PADDING for works of art. It is available in varying thicknesses and textures, ranging from transparent sheeting (such as MYLAR®) to NONWOVEN FABRIC (such as PELLON®). It is impervious to moisture, dimensionally and chemically stable, and resistant to mold. ARCHIVAL-quality polyester contains no plasticizer coating or colorant.

Polypropylene. A PLASTIC with high chemical resistance, CORROSION resistance, and heat and freezing resistance, but degraded by ULTRAVIOLET (UV) light. It is permeable to air and MOISTURE VAPOR but will protect against liquid water. Polypropylene can be made in sheet form or molded, can have specific properties such as dust and dirt resistance by incorporating ANTI-STATIC additives, and is used for a wide variety of art-preservation products and applications. Among them are NONWOVEN absorbing products for emergency water spills, reusable plastic storage containers, tubing, and polypropylene sheeting, a translucent, flexible but strong BARRIER MATERIAL. Not all grade levels are sufficiently INERT to be used with works of art.

Polyvinyl acetate (PVA, also known as PVAC). *See* Adhesives: White glue.

Powder-coated metal shelves (epoxy powder coated). Powder-coated metal used for open shelving, flat files, and cabinet storage, as opposed to metal or wood shelving finished with conventional liquid paint, does not require a solvent but is applied electrostatically and cured, thus emitting near-zero VOLATILE ORGANIC COMPOUNDS that can severely damage ORGANIC and INORGANIC works of art (*see* Woods). Powder-coated finishes, which are complex to apply to surfaces, have high chemical resistance and are harder and tougher than conventional paint, thus offer chip resistance. These coatings will break down in about ten years when continuously exposed to ULTRAVIOLET (UV) light.

Preservation. An aspect of conservation and COLLECTIONS CARE dealing with the long-term protection of art objects and cultural property by implementing measures to minimize chemical deterioration and avoid physical damage. Among these measures are: maintaining optimal environmental conditions in exhibition, storage, and in transit; employing appropriate handling practices; use of stable, nondetrimental materials for storage, exhibition, and transit; implementing INTEGRATED PEST MANAGEMENT and emergency preparedness protocols (see Chapter 21); and ensuring that appropriate conditions are maintained for objects in photography, in transit, and on loan.

Preventative conservation. An aspect of COLLECTIONS CARE that entails procedures to mitigate deterioration and damage. It is based on the premise of preserving works of art and reducing the need for interventive treatment. *See* Preservation.

Proteinaceous materials. Art objects composed of proteins (determined by the relative amounts of amino acids present), which are the ORGANIC compounds found in animals or in the protective coatings of many microorganisms. Materials having a protein base include but are not limited to parchment, leather, bone, horn, ivory, wool, silk quills, feathers, egg tempera, animal glues, egg binders, casein adhesives, and binders. Being organic, many of these materials are highly vulnerable to deterioration from adverse environmental conditions, inappropriate LIGHTING, and BIODETERIORATION. *See* Inorganic objects; Cellulosic.

R

Rag paper or board. *See* Paper and paper products.

Recording hygrothermograph and hydrograph. *See* Humidity meters.

Recto. A term designating the front of a work on paper or photograph, or the right side of an open book.

Relative humidity (RH). A measure of the amount of moisture (water vapor) in the air relative to the amount the air is capable of holding at a given temperature and pressure. Changes in RH depend upon the introduction or loss of moisture or a change in temperature. RH is expressed as a percentage, for example, at 2%RH the air is bone dry, and at 100% it is completely saturated and condensation will form on cold surfaces. It is a vital measurement in maintaining the condition of artworks. *See* Humidity meters.

Rubber. Material chemically and physically detrimental to works of art owing to its sulfur content. Over time, rubber bands, rubber cement, rubber ERASERS, rubber GLOVES, and other rubber-based products will stain ORGANIC materials and TARNISH metals. Rubber will also lose flexibility, strength, and adhesive properties. Such materials should never be used with art objects.

S

Salt. The term used in conservation to describe a precipitate forming on or within an object. This is provoked by moisture interacting with compounds within the fabric of the object, from the migration of compounds in soil into an object occurring during its burial,

or from storage in an ACIDIC environment such as an oak cabinet or plywood case. A salt is any compound formed by a pair of positive and negative ions. Salts may be found in archaeological materials, glass, metals, pottery, paper, or textiles and appear as crystal, EFFLORESCENCE, or a powdery bloom.

Sandbags. *See* Padding; Weights

Scavengers. Materials that are used for the passive control of gaseous pollutants in an enclosed space in order to protect art objects from CORROSIVE damage. Most contain ACTIVATED CARBON as well as other chemical media and act by chemical and physical absorption. OXYGEN SCAVENGERS absorb oxygen; PACIFIC SILVERCLOTH® absorbs gaseous sulfur, Scavengel® removes a broad range of common indoor gaseous pollutants. *See* Ageless®; Zeolites.

Self-adhesive linen tape. *See* Tape.

Silica gel. A chemically INERT material that can absorb and release moisture and thus serves as a BUFFER against RELATIVE HUMIDITY (RH) changes, passively maintaining RH at a stable level in an enclosed space, or MICROCLIMATE. Silica gel is available as loose beads (but will cause harmful dust in this form), in sachets, incorporated into board and felt (ART SORB®), or embedded in POLYESTER sheet (RHapid Gel®). It is used as a component of housing, exhibition, or storage cases but should not come in direct contact with works of art, thus must be placed, for example, in compartments beneath a VITRINE or at the back of a framed object. Silica gel must be conditioned to the desired level of RH. To reutilize it, silica gel must be periodically reconditioned.

Silicone release film and paper. Isolating, antistick BARRIER sheeting composed of a substrate (transparent POLYETHYLENE or POLYESTER, or paper) and a silicone coating used for segregating an object from surrounding wrapping or PADDING that otherwise may adhere. Silicone paper should not be used with photographs or with friable media.

Sling psychrometer. *See* Humidity meters.

Solander boxes. Sturdy buckram-covered and paper-lined WOOD boxes used for the storage of prints, drawings, photographs, miniatures, and unframed pastels, among other objects. The hinged lid fits over flanged sides, making the box dust- and LIGHT-proof. The name is derived from the type of box used for natural history specimens by the eighteenth-century botanist Daniel Solander. ARCHIVAL boxes made from ACID-FREE cardboard are used for similar purposes.

Spalling. The FLAKING and loss of surface from a larger solid body, such as ceramic and stone objects and external architectural masonry. It is generally caused by the infiltration of moisture that expands upon freezing, pushing off the surface or outer layer of the material. Spalls refer to flakes from the surface or edge of such materials.

Spray cleaners and impregnated cloths. Such cleaning agents, which are also used to reduce STATIC CHARGE, must only be applied to the exterior of glass, acrylic surfaces, and VITRINES. Liquid cleaning solutions should be sprayed on a cloth that is then applied to the housing, mount, or GLAZING, and never applied directly to the plastic or glass housing, in order to avoid the risk of seepage onto an art object. Impregnated cloths are

useful for removing excess dust on platforms and cases where VACUUMING might be difficult.

Static charge. *See* Anti-static.

Strapping tapes. Various materials used to secure objects in place while on exhibition and in transit. Strapping materials that are in direct contact with an art object must be INERT, nonabrasive, and have adequate strength to secure it. The method by which the object is secured should be determined by a conservator or trained technician. For large objects such as sculpture and framed works, padded ropes or nylon straps may be used. Cotton twill (woven cotton ribbon), POLYPROPYLENE or JAPANESE PAPER can be used for small objects, such as books, scrolls, photographs, works on paper, and textiles.

Swiffers®. *See* Dust removers.

Synthetics. Man-made materials used for works of art as well as display and storage materials. Synthetic compounds are formed through chemical processes but may be derived from natural substances, such as CELLULOSIC products. *See* Plastic.

T

Tap water. Local, geological, or reservoir conditions affecting groundwater, and the type and the condition of pipe materials (such as galvanized steel, copper, and plastic), will affect the presence of various substances in water taken from a faucet. Depending on whether the water is hot or cold, these substances can include biological and chemical contaminants (such as mineral deposits of calcium carbonate in hard water), metal ions (such as magnesium and iron), and gases (such as hydrogen sulfide). The mineral and particulate matter from untreated tap water varies greatly depending upon the source of the water and the pipes through which it travels. It therefore may be detrimental to art objects and should not be used for preservation/conservation purposes without the advice of a conservator. The same holds true for bottled water, which may contain contaminants.

Tape. Adhesive tape may be made with a variety of carriers (paper, linen, GLASSINE, POLYESTER) and many types of ADHESIVES (acrylics, RUBBER derivatives, gums, etc). **Pressure-sensitive tapes** are invariably detrimental to works of art. The adhesive component of commercial tapes (transparent or masking) tends to migrate through porous material and cause discoloration. They are difficult to remove and may detach damaged glazes on ceramics, lift paint layers, and abrade fibrous materials. **"Archival tapes"** (ACID-FREE paper carriers with acrylic adhesives) are very difficult to reverse and should not be in contact with works of art. **Gummed cloth and paper tapes** (glassine tape), coated with gum Arabic, methylcellulose, or water-soluble adhesive, require moisture to activate and pressure to set, and are generally less detrimental than pressure-sensitive tapes; however, some adhesives can stain the work of art. Tapes should not be used in contact with works of art in any medium without the advice of a conservator. Some tapes, such as archival paper tape, gummed cloth tape, and gummed KRAFT PAPER tape, can be used for constructing housing such as boxes and folders and for storage wrapping. These tapes also can be used for dust sealing the gaps in frames (*see* MarvelSeal®). **Double-sided transparent tape** on a polyester film substrate with an INERT acrylic adhesive is used to secure MARVELSEAL® and for MYLAR®

ENCAPSULATION. **Low-tack tape** is used to reduce damage from shattering glass on framed works that will be transported.

Tarnish-resistant cloth. *See* Pacific Silvercloth®; Scavengers.

Tissue. *See* Paper and paper products.

Tycore®. A dimensionally stable, warp-free, and light-weight mounting panel of high compression strength made with a honeycomb interior core of ACID-FREE, lignin-free paper faced on the back and front with acid-free, BUFFERED paperboard adhered with ARCHIVAL-grade PVA ADHESIVE. It is cut with a bandsaw. For art-preservation purposes, it is often used as a mounting substrate or rigid support for works of art.

Tyvek®. High-density POLYETHYLENE, NONWOVEN FABRIC without fillers or binders. Its fine, white, continuous filaments are spun-bonded by heat and pressure, creating high-strength, thin, soft, and smooth lint-free sheets. For art-preservation purposes, this light-weight material, which may be written on for labeling, is used for wrapping and storage of objects, as a tray lining for the examination of objects, and as disposable laboratory and protective emergency clothing. It is waterproof yet allows for moisture vapor exchange. Sealed Tyvek®, like MYLAR®, and other plastic films and bags, may create an unfavorable microclimate if condensation develops during adverse atmospheric conditions.

U

Unbuffered paper. *See* Paper and paper products; Buffer.

Ultraviolet (UV) light. *See* Light, lighting.

V

Vacuum cleaning. Depending upon the collections area or the individual object being cleaned, several factors should be taken into consideration when using a vacuum cleaner: that it is fitted with a HEPA FILTER for the removal of hazardous particles and mildew spores; that it has a rheostat to control the strength of the suction; and that gauze or mesh screening is applied to the nozzle of the hose to prevent damage to the surface being cleaned and to prevent the pick-up of loose elements such as threads or fragments. A vacuum cleaner, even with a protected nozzle, should never be used to remove dust from objects that are subject to FLAKING, have porous or rough surfaces, or have loosely adhered parts. A conservator should determine if a vacuum is appropriate to the areas or object being cleaned and the technique to be employed. *See* Nilfisk®.

Vapor barrier. Materials that prevent the transfer of moisture vapor and gases and are used for constructing MICROCLIMATE environments. *See* Moisture and gaseous vapor barriers.

Verso. A term designating the back of a work on paper or photograph, or the left side of an open book or pamphlet.

Visible light. *See* Light, lighting: Daylight.

Vitrine. An exhibition case or enclosure made from GLASS or ACRYLIC SHEETING that protects art objects from physical damage and climate changes. A vitrine may be freestanding, mounted on a pedestal or wall mounted, sealed to create a MICROCLIMATE, and equipped with SCAVENGERS to preclude gaseous pollutants.

VOCs. *See* Volatile organic compounds.

Volara®. ARCHIVAL-quality, closed-celled, flexible POLYETHYLENE FOAM available in continuous rolls and sheets in several thicknesses that may be readily cut to size. It is soft, smooth, and nonabrasive, textural properties that make Volara® without colorants suitable for cushioning and PADDING art objects for storage, for lining drawers, shelves, and examination trays, and for wrapping. It has low water absorption, low moisture vapor permeability, high chemical and temperature resistance, and is nontoxic.

Volatile organic compounds (VOCs). ORGANIC chemical compounds that have significant vapor pressure. They are numerous, ubiquitous, and damaging to works of art. They are emitted by man-made and naturally occurring products, for example, WOOD, plants, fossil fuels, PLASTICS, SYNTHETIC materials, solvents, PAPER, ADHESIVES, paints, and protective coatings, and can be emitted from materials when fresh or in the process of deterioration. Many materials used in the construction of art storage and display cases slowly emit formaldehyde and other VOCs. Vaporization, or off-gassing, is accelerated by high temperature and humidity. In enclosed units, such as MICROCLIMATES, the buildup of VOCs can cause deterioration of the organic and INORGANIC works of art contained within, therefore such units should be periodically opened; similarly, low rates of air exchange can cause VOC buildup in storage areas or units. Ventilation and air conditioning are helpful in reducing VOC emissions in such areas.

W

Wax paper. *See* Paper and paper products.

Wedges. *See* Padding.

Weights. Sandbags, covered lead or lead shot, sewing weights, glass rods and plates used in positioning a work of art so that it remains stable during examination or exhibition. Unless they have a nonabrasive and INERT surface, weights should be covered or separated from the work of art by a BARRIER MATERIAL.

Wet and dry bulb hydrometer. *See* Humidity meter.

Weeping glass. Deterioration provoked by atmospheric moisture in unstable GLASS, usually resulting from an excess of alkali or a deficiency of stabilizer in its composition. Atmospheric moisture dissolves the alkaline components that under drier conditions evaporate, resulting in CRIZZLING, a BLANCHED surface with a network of fine cracks. The condition is progressive and can be slowed only by environmental control.

Wheat starch paste. *See* Adhesives.

White glue. *See* Adhesives.

Woods. Hardwoods, such as oak, cherry, chestnut, which were once commonly used for exhibition and storage cases and shelving, tend to emit volatile corrosive vapors, such as carboxylic ACIDS, which are highly damaging to metals, glass, and ceramics and can provoke SALT formation on these objects. These woods are equally detrimental to ORGANIC objects such as paper and textiles. Works of art should not be kept in these housings or in proximity to wood backboards unless these materials are sealed with VAPOR BARRIERS. *See* Composite woods.

Z

Zeolites. Natural mineral and synthetic crystalline substances that are highly porous and act as molecular traps, or SCAVENGERS, for gaseous pollutants. For preservation purposes, zeolites are incorporated into paperboard and ARCHIVAL housing material, such as RAG BOARD, thus help to stabilize objects and artifacts by adsorbing volatile organic ACIDS released by collection items' display and storage cases as they degrade; external pollutants such as nitrogen and sulfur dioxide; and internal pollutants from, for example, cleaning solutions, construction materials, and painting materials. Paperboards containing zeolites are more effective than nontreated boards in trapping the byproducts of deterioration, and are capable of rendering such gases inactive. They may be combined with alkaline substances to neutralize free acids. Zeolite boards can release acidic vapors if they are moved to a less polluted environment, thus replacement rather than reuse of these materials should be considered. *See* Ageless®; Scavengers; Activated carbon.

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