NATIONAL PARK SERVICE

Conserve O Gram

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Mold: Prevention Of Growth In Museum Collections

Mold is the common term used to describe a downy or furry growth on the surface of organic matter, caused by fungi, especially in the presence of dampness and decay. A fungus (pl. fungi) may be any of a large number of microorganisms that are parasites feeding on living organisms or dead organic matter. There are approximately 1.5 million mold species, each requiring different environmental conditions to survive. Mold can produce irregular stains that may permanently damage an object. Collection managers must be able to recognize signs of these problems and be prepared to take preventive actions.

The Microorganisms

Fungi are simple-celled organisms that do not need energy from light for growth. Fungi bear microscopic spores that are produced in enormous quantities. Fungal spores are normally present in the air and spread via air currents. They are often water repellant and resistant to desiccation (drying out). Extreme cold, freezing, and heat deactivate spores or spore growth but do not kill them. If temperatures go up after cold, spores can be reactivated and mold will continue to grow.

When the spores are in a favorable environment, they will germinate. Favorable environments are different for each species. Relative amounts of each species vary with geography, seasons, and local weather conditions, and differ indoors and outdoors. After landing on a host material, a spore must obtain sufficient moisture and nutrients to germinate. Mold growth will accelerate after germination under a combination of the following conditions: elevated temperature, poor air circulation, dim light, or accumulated dirt. Without moisture, the spores lie dormant until favorable conditions occur. For this reason, it is important to control the environmental conditions where museum collections are stored or exhibited. See the NPS *Museum Handbook*, Part 1, 4:13 for specific environmental recommendations.

Health Hazards

Some people are more at risk to mold hazards than others, such as those who suffer from respiratory problems, severe allergies, diabetes, and compromised immune systems. High concentrations of non-toxic molds can cause allergies in previously non-sensitive people, causing allergic reactions, respiratory problems, dizziness, or headaches. Permanent sensitization can occur. Killing mold does not eliminate all health hazards. Inactive mold may cause allergic reactions in sensitive people. Certain species of microorganisms cause health risks such as chronic lung irritation. Some molds are toxins as well as allergens.

Always exercise caution when handling infested materials by wearing a high-efficiency particulate air (HEPA) filter respirator, goggles, dis-

posable gloves, and a washable lab coat that can be cleaned with a bleaching agent in water. Extensive contamination may require personal protective equipment that can be worn over clothing, such as a disposable Tyvek suit. See COG 16/1.

Susceptible Materials

Mold needs organic materials to supply nutrients and, therefore, museum objects composed of organic materials are potentially at risk. Cellulose-based materials, such as cotton, linen, paper and wood, and proteinaceous materials such as leather, parchment, adhesives and hair cloth are particularly susceptible to direct attack by microorganisms.

Inhospitable materials, such as plastics, are not immune to fungal growth, but how they support growth is not fully understood. Certain insects feed on fungi and can carry spores onto normally resistant materials. As the insects die, they become the nutrients for a new fungal colony. This ability to exist on almost any material characterizes mold as a primary agent of deterioration.

Damage

Mold can permanently damage the materials supporting it, and make them more susceptible to future mold contamination. It can stain wood, textiles and paper, and decrease the strength of their structures, making them more porous and fragile. Fungi may cause loss of protein or starch sizing in paper materials, causing them to absorb water more easily. These growths can result in scattered spots, known as foxing, on paper prints or drawings. Leather is particularly susceptible to mold and can be stained and weakened by it.

As a by-product, fungi can produce organic acids that will corrode and etch inorganic materials, such as metals. Fungi can excrete pigments (both soluble and insoluble), metabolic products that color with age, enzymes that digest organic materials, odors, allergens, and toxins.

Detection

Often the first indication that a mold problem exists is a characteristic musty odor. Careful visual examination will generally locate stains that are clearly visible as pigmentations on the surface of a material. Mold can appear as a velvety growth of almost any color, or a powdery deposit. Ultraviolet (UV) light is used to detect mold. Under UV light, mold growth appears luminescent. See NPS COGs 1/9 and 1/10 for the use of UV light in examining objects.

Mold is associated with malfunctioning or unclean humidifiers, standing water, poor housekeeping, poor ventilation, or water damage to an object.

Prevention

The best means to prevent or control the spread of fungal growth is to deny the spores the moisture necessary for germination. Regulating the environment, especially the relative humidity (RH), is essential for preventing the deterioration of a museum collection from microorganism growth.

Routinely monitor RH levels, and keep temperature and RH levels as constant as possible. Spore germination is less likely if RH is controlled between 45 % and 55 %. RH should ALWAYS be kept below 65%. When RH levels rise above 65 %, the use of portable

dehumidifiers is necessary to reduce the moisture content of the air. Target temperature is between 18°C and 20°C (64°F to 68°F). These conditions only reduce the potential for microorganism growth. They do not eliminate the threat. Some microorganisms can grow in significantly lower temperatures and at lower RH levels. Certain materials need to be stored with lower RH levels to prevent growth.

Refer to the NPS *Museum Handbook*, Part 1 Figure 4.2, for the RH target levels for various materials and objects types housed in park museum collections.

Maintain other environmental factors, such as adequate air circulation, to decrease potential of mold germination and growth. A fan helps increase circulation. Proper ventilation can help keep materials dry, prevent mold spores from landing on objects, and reduce microclimates with high RH levels. Correct environmental conditions that contribute to high humidity. Repair leaking pipes, gutters and downspouts, cracked windows, problem roofs, deteriorated brick, masonry pointing, or cracked walls. Change air filters regularly, insulate cold water pipes, ventilate crawl spaces if possible, and maintain HVAC systems.

Avoid storage in or near damp areas such as attics, basements, sinks, windows, or directly on floors. Store all collection materials at least four inches above the floor. Avoid storing collection materials directly against outside walls where they are more susceptible to high RH, condensation, and leaks from upper floors.

Keep areas housing museum collections clean and free of dust, dirt and organic debris that can nourish spores. Use dust covers over objects in storage if they are not contained in cabinets or drawers. Seal display cases well.

Silica gel and other buffers can help adjust RH conditions in a sealed space, such as a storage cabinet, specialized storage enclosure or an exhibit case. These buffers absorb or release moisture into the surrounding atmosphere. See NPS *Museum Handbook,* Part I, Appendix I and COG 1/8 on using silica gel in microenvironments. Customize the quantity of buffering material to place within the space for each situation. Consult a conservator to determine this need. Monitor to ensure that the buffers perform as intended.

Include procedures for dealing with mold in park wide and museum-specific disaster plans. Have procedures in place for the inspection of new accessions. Isolate new accessions until it is clear they are free of mold.

Treatment

Inspect new accessions before moving them into storage. Inspect the collection regularly for signs of visible mold growth or the telltale 'musty' smell. If an object shows signs of infestation, seal it in a polyethylene bag or enclose it in polyethylene sheeting to prevent the spread of spores to other objects. Do not touch the mold, as this will spread the spores.

Remove the object to an isolated space where the RH can be lowered by running a dehumidifier, and try to determine the cause and extent of the growth. Contact a conservator for assistance in dealing with the infested material.

Deactivation options for mold include air drying at a temperature between 30°C and 40°C (86°F and 104°F), freeze drying, exposure to ultraviolet light or sunlight, and gamma radiation. Consider these options in consultation with a conservator, as objects can be damaged with inappropriate treatment. Note: If

temperature or RH goes up after deactivation, spores can be reactivated and mold will continue to grow.

Vacuuming dried mold is appropriate in most situations. Only vacuum if you are sure that the mold is dry and powdery. Remove the object from the polyethylene the bag or sheeting and discard the polyethylene. Vacuum it using a vacuum cleaner that does not exhaust spores back out into the room. A vacuum fitted with a HEPA filter is recommended; however, the water bath filter vacuum cleaner is acceptable for this purpose. Follow all precautions when vacuuming an object: use the lowest effective suction and protective screening. (See NPS *Museum Handbook*, Part I, Appendix K:35, for vacuuming procedures.) Work in a biological fume hood if available. If necessary, use a soft brush to dislodge tenacious mold. Wear disposable latex or nitrile gloves when handling a contaminated object. Seal the vacuum cleaner bag, gloves and other contaminated materials in a plastic bag and dispose of them in the trash outside the building. Dispose of all contaminated storage materials that were used to store the object.

Only consider chemical eradication of a fungal infestation with a biocide capable of killing the growths in consultation with the Regional Integrated Pest Management (IPM) coordinator and regional curator. Submit a proposal for chemical use to, and receive final approval from the Servicewide IPM coordinator, WASO. (See NPS *Museum Handbook*, Part I, Chapter 5, for guidance.) Use must conform to NPS and Environmental Protection Agency restrictions and guidelines.

Consult a conservator with a specialization in the materials to be treated to review the possible effects of any chemical on the object.

Biocide could itself become a potential nutrient for certain types of fungus as it breaks down, so treatment is specific to material type and must be done under the advice of a conservator.

Sources

UV lamps are available through most hardware stores. Silica gel is available from suppliers of conservation and archival-quality materials. HEPA filter respirators, disposable gloves, goggles, and lab coats are available from laboratory supply companies. HEPA filter vacuums are available through laboratory supply companies, and from companies providing professional cleaning equipment. (See COG 1/6 on choosing a vacuum cleaner for museum collections). Sources for these supplies are listed below.

Gaylord Bros., Inc.
PO Box 4901
Syracuse, NY 13221-4901
(800) 448-6160
http://www.gaylord.com/

Talas
20 West 20th Street, 5th Floor
New York, NY 10011
(212) 219-0770
http://www.talasonline.com/

3M Corporate Headquarters
3M Center
St. Paul, MN 55144-1000
(888) 3M-HELPS
http://solutions.3m.com/en_US/

Fisher Scientific
2000 Park Lane Drive
Pittsburgh, PA 15275
(800) 766-7000
https://www.fishersci.com/

Lab Safety Supply
P.O. Box 1368,
Janesville, WI, 54547-1368
(800) 356-0783
http://www.labsafety.com/

Nilfisk of America
300 Technology Drive
Malvern, PA 19355
(213) 647-6420
http://www.nilfisk-advance.com/

Rexair LLC (distributor of Rainbow vacuums)
50 West Big Beaver, Suite 350
Troy, MI 48084
(248) 643-7222
http://www.rainbowsystem.com/eng

Jane Merritt, former Textile Conservator
National Park Service
Harpers Ferry, West Virginia 25425

Revised by Tish Brewer, Assistant Paper Conservator, 2007
National Park Service
Harpers Ferry, West Virginia 25425