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EMERGENCY MANAGEMENT

**3.8 Emergency Salvage of Moldy Books and Paper**

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**Introduction**

Most librarians and archivists have seen the effects of mold on paper materials, but many have never experienced an active mold outbreak. Dealing with such an outbreak (large or small) can be overwhelming. This leaflet provides some basic information about mold and outlines the steps that need to be taken to stop mold growth and begin to salvage collections.

Please note that the actions recommended here are basic stabilization techniques to be undertaken in-house for small to moderate outbreaks. The complexities of dealing with a large number of wet and moldy materials will usually require outside assistance, and some suggestions for dealing with a major mold outbreak, appear at the end of this leaflet. In all cases, a conservator or preservation professional should be consulted if any questions arise or if further treatment is necessary.

**What is Mold?**

Mold and mildew are generic terms that refer to various types of fungi, microorganisms that depend on other organisms for sustenance. There are over 100,000 known species of fungi. The great variety of species means that patterns of mold growth and the activity of mold in a particular situation can be unpredictable, but it is possible to make some broad generalizations about the behavior of mold.

Mold propagates by disseminating large numbers of spores, which become airborne, travel to new locations, and (under the right conditions) germinate. When spores germinate, they sprout hair-like webs known as mycelium (visible mold); these in turn produce more spore sacs, which ripen and burst, starting the cycle again. Molds excrete enzymes that allow them to digest organic materials such as paper and book bindings, altering and weakening those materials. In addition, many molds contain colored substances that can stain paper, cloth, or leather. It is also important to realize that mold can be dangerous to people and in some cases can pose a major health hazard. Mold outbreaks should never be ignored or left to "go away on their own."

**Why Does Mold Grow?**

To germinate (become active), spores require a favorable environment. If favorable conditions are not present, the spores remain inactive (dormant); in this state they can do little damage.

The most important factor in mold growth is the presence of moisture, most commonly in the air, but also in the object on which the mold is growing. Moisture in the air is measured as relative humidity (RH). In general, the higher the RH the more readily mold will grow. If the RH is over 70% for an extended period of time, mold growth is almost inevitable. It is important to remember, however, that it is possible for some species of mold to grow at lower RH as well. If collections have become wet as the result of a water disaster, this increases their susceptibility to mold growth. Other factors that will contribute to mold growth in the presence of moisture are high temperature, stagnant air, and darkness.

Mold spores, active or dormant, are everywhere. It is not possible to create an atmosphere free of spores. They exist in every room, on every object in the collection, and on every person entering the collection area. The only wholly dependable control strategy is to keep the humidity and temperature moderate so

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the spores remain dormant, keep collections as clean as possible, and prevent the introduction of new active mold colonies.

### Basic Principles of Salvage

**Reduce the humidity:** As noted above, moisture initiates mold growth. Reducing the humidity is essential to stopping the mold growth.

**Do not turn up the heat:** This will not help to dry out collections and storage areas. Additional heat in the presence of moisture will cause the mold to grow faster.

**If collections are wet, dry or freeze them:** Mold will normally grow on wet materials in about 48 hours (sometimes sooner). If you know you cannot get the affected material dry within 48 hours, it is best to freeze it. This will not kill the mold, but it will stop further growth until you have a chance to dry and clean the material.

**Consider the health risks:** A few mold species are toxic to people, and many molds are powerful sensitizers. Exposure to mold can lead to debilitating allergy even among people not prone to allergies. Everyone who works with moldy objects must be properly protected.

**Avoid "quick and easy" cures:** "Quick cures" that you may have heard about (such as spraying Lysol on objects or cleaning them with bleach) may cause additional damage to items or be toxic to people; they are also often ineffective. In the past, mold-infested collections were often treated with fumigants. Ethylene oxide (ETO) will kill active mold and mold spores; other chemicals that have been used are less effective. All of these chemicals can have adverse effects on both collections and people, and none of them will keep the mold from recurring.

### Step-by-Step Salvage

This section provides specific steps for responding to a small or moderate mold outbreak. While the steps are numbered for convenience, they may not be carried out in exactly this order, and some of these activities will occur simultaneously.

1. Find out what is causing the mold growth. You need to know what is causing the problem so that additional mold on collections not yet affected can be avoided.
  - Look first for an obvious source of moisture, such as a water leak.
  - If there is no obvious source of moisture, use a monitoring instrument to measure the relative humidity in the affected area. If the humidity is elevated, there might be a problem with the HVAC (heating, ventilating, and air conditioning) system, or the area might be subject to higher humidity for another reason, such as having shelves placed against an outside wall. Mold might also develop in areas with poor air circulation or in areas where there is a lot of dust and dirt that might provide a food source for mold.
  - Initiate repairs or resolve the problem as soon as possible. If the problem cannot be resolved quickly, salvage the collections as directed below and develop a strategy for frequent monitoring of the area for additional mold growth.
2. Take steps to modify the environment so that it is no longer conducive to mold growth.
  - Mop up and/or use a wet-dry vacuum to remove any standing water. Bring in dehumidifiers, but be sure that a mechanism is in place to drain them periodically so they do not overflow. Bring in fans to circulate the air, and open the windows (unless the humidity is higher outside).
  - Your goal should be to reduce the relative humidity to 55% or lower. Temperature should be moderate, below 70°F. Get a monitoring instrument that can measure the relative humidity and temperature accurately, and record the measurements in a log several times a day. Do not rely on your own impression of climate conditions.
3. Implement safety precautions for staff and others working with moldy items.
  - A mycologist should be consulted to insure that no toxic mold species are present (a local hospital or university should be able to provide a reference). If toxic molds are present, DO NOT attempt to salvage materials yourself.
  - If there are no toxic molds present, collections can be salvaged in-house, but everyone working with the affected materials must wear disposable plastic gloves and clothing, and use a protective mask when working with moldy objects.

- Use a respirator with a HEPA (high efficiency particulate) filter; pollen dust masks available in drug and hardware stores are not adequate. If you cannot use disposable clothing, be sure to leave dirty clothes in a designated area and wash them in hot water and bleach. Respirators should be wiped periodically with rubbing or denatured alcohol.
  - Be aware that some people cannot wear respirators. The respirator must fit well with good contact around the nose and mouth area. In addition, they make breathing somewhat difficult and can be problematic for people with asthma or heart conditions, or people who are pregnant. It is a good idea to consult your doctor before wearing a respirator to work with moldy materials.<sup>1</sup>
4. Isolate the affected items.
- Quarantine items by removing them to a clean area with relative humidity below 45%, separate from the rest of the collection. Items should be transferred in sealed plastic bags to avoid transfer of mold to other items during the move, but they should not remain in the bags once in the clean area, since this will create a micro-environment that can foster further mold growth.
  - In the case of a large mold outbreak it may be impractical to move the items; in that case the area in which they are housed should be quarantined and sealed off from the rest of the building to the extent possible (remember that this includes shutting off air circulation from the affected area).
5. Begin to dry the materials. Your goal is to make the mold go dormant, so that it will appear dry and powdery rather than soft and fuzzy. This will allow you to remove the mold residue more easily.
- Wet material should be dried in a cool, dry space with good air circulation. An air-conditioned space is the best for this purpose, but if that is impossible, use fans to circulate air (do not aim fans directly at objects, however, as this can damage materials and further scatter mold spores). Place paper toweling or unprinted newsprint (regular newspapers may transfer print to the wet objects) under the drying items to absorb moisture, and change this blotting material often. Air drying takes time and attention, since you must check drying materials often, and you must maintain cool, dry conditions and air circulation in the space.
  - Collections may also be dried outside in the sun (sunlight or ultraviolet light can cause some molds to become dormant). The outside humidity must be low. Be aware that the sun causes fading and other damage to paper-based collections, however. Materials should be monitored closely and left outside no more than an hour or so.
  - Special attention should be paid to framed objects (such as prints and drawings) and to the interior of the spines of books. A frame provides an ideal environment for mold; the back is dark, air does not circulate, and humidity can be trapped inside. Similarly, the interior of the spine of a book is particularly vulnerable to mold growth. Spines should be checked regularly during the drying process. Framed materials should be unframed immediately, and dried as above. If the item appears to be stuck to the glass in the frame, remove the backing materials from the frame and leave the item in the frame and attached to the glass. Place the framed item in a cool, dry space as described above, and consult a professional conservator.
6. If immediate drying is not possible, freeze the affected items.
- If the item is small enough, it can be placed in the freezer compartment of a home refrigerator, with freezer paper loosely wrapped around it to prevent it from sticking to other items.
  - For items that are too big for a freezer compartment or for larger numbers of items, a commercial freezer may be necessary (grocery store, university food service, commercial cold storage facility, etc.). It is a good idea to make arrangements for commercial freezer storage before an emergency arises, since there may be restrictions on storing moldy items in a freezer that normally holds foodstuffs.
  - Once time and resources are available, frozen materials can be thawed and dried in small batches, or they can be freeze-dried or vacuum freeze-dried (with the exception of photographs, which should not be freeze-dried or vacuum freeze-dried).
7. Clean the affected items. **Do not** try to clean active mold (soft and fuzzy) yourself. This should be done only by a conservator, who will use a vacuum

aspirator to avoid further embedding the mold into the paper. The following instructions apply only to inactive (dry and powdery) mold and materials that do NOT have artifactual value:<sup>2</sup>

- Remove mold residue outdoors rather than in an enclosed space whenever possible. Be sure to wear protective gear (see above). If you must work indoors, use a fume hood with a filter that traps mold or in front of a fan, with the fan blowing contaminated air out a window. Close off the room from other areas of the building (including blocking the air circulation vents).
  - Vacuum the mold. Use a vacuum with a HEPA filter; this will contain the mold spores. A normal vacuum will simply exhaust the spores out into the air. You can also use a wet-dry commercial-strength vacuum if the tank is filled with a solution of a fungicide such as Lysol diluted according to the label instructions. A tube from the hose inlet should extend into the solution so that incoming spores are directed there.
  - Do not vacuum fragile items directly, since the suction can easily cause damage. Papers can be vacuumed through a plastic screen held down with weights. A brush attachment covered with cheesecloth or screening should be used for books to guard against loss of detached pieces. Boxes can be vacuumed directly. When disposing of vacuum bags or filters, seal them in plastic trash bags and remove them from the building.
  - It is also acceptable to clean off mold with a soft brush, but this must be done carefully. Once moldy material is dry and the residue appears powdery, take a soft, wide brush (such as a watercolor wash brush) and lightly brush the powdery mold off the surface of the item. This should be done outside or the mold should be brushed into a vacuum nozzle. Be careful not to rub the mold into the surface, since that will attach it permanently to paper fibers or the cover of a book.
8. Dry and thoroughly clean the room(s) where the mold outbreak occurred. You may do this yourself or hire a company to provide dehumidification and/or cleaning.
- Vacuum shelves and floors with a wet-dry vacuum filled with a fungicide solution such as Lysol, then wipe them down with Lysol or a similar solution. Allow them to dry fully before returning any materials. If a musty odor lingers in the room, open containers of baking soda may help.
  - It is also a good idea to have the HVAC system components (heat-exchange coils, ductwork, etc.) cleaned and disinfected, particularly if you suspect they have caused the problem.
9. Return materials to the affected area. Do this **only** after the area has been thoroughly cleaned **and** the cause of the mold outbreak has been identified and dealt with.
10. Continue to monitor conditions and take steps to avoid additional mold growth.
- Take daily readings of temperature and relative humidity, and be sure that the climate is moderate. It is particularly important to keep humidity below 55% to insure that mold will not reappear. Temperature should not exceed 70°F.
  - Check problem areas frequently to insure that there is no new mold growth. Be sure to examine the gutters of books near the endbands and inside the spines.
  - Keep areas where collections are stored and used as clean as possible, since dust and dirt are a source of spores, both active and dormant. Clean floors with a HEPA filter vacuum rather than sweeping, since sweeping scatters dust. House collections in protective enclosures whenever possible to keep them free of dust. Vacuum shelves and the tops of unboxed, shelved books, or clean them with a magnetic wiping cloth.
  - If funds permit, install a multi-stage particulate filtration system in the building or storage area.
  - Keep windows closed to prevent active spores from entering, and prohibit live plants in collection storage or use areas, since these are also a source of spores.
  - Quarantine new acquisitions for a few days, and check them carefully for signs of mold.
  - Avoid storing collections in potentially damp areas or in locations where water accidents are possible. Insure that regular maintenance is carried out on the building to reduce the chance of water emergencies.

- Regularly inspect the HVAC system, which is a good breeding ground for mold. Regularly clean the heat exchange coils, drip pan, and ductwork. Change air filters frequently.
- Prepare a disaster plan. This will prevent some accidents and provide strategies for dealing quickly and effectively with problems. Be sure that all employees are familiar with the plan.

### Dealing with a Major Mold Outbreak

If a large portion of the collection is affected by the mold outbreak, if dangerous species of mold are present, or if the HVAC system and the building itself are also infected with mold, outside assistance will be needed. Particularly in the latter cases, it is essential to make sure that the building is safe for occupancy by staff. There are a variety of companies experienced in working with cultural collections that can assist institutions with recovery.

Most of the disaster recovery companies that provide drying services will also clean surface mold off collections. Conservators or regional conservation centers provide treatment services for individual items with artifactual value.

There are also several disaster recovery companies that specialize in dehumidifying and cleaning of buildings. In the case of a severe infestation of mold and/or an infestation that poses serious health risks to staff, companies specializing in indoor air quality can help to insure that the building is safe for occupancy. In severe cases, fumigation of the affected area may be necessary. Due to the potential for damage, fumigants should not be used directly on or in the presence of collections unless there is no other choice. Fumigation should always be done by a licensed professional.

A list of service providers is given at the end of this leaflet. Be sure that the company you choose is familiar with the requirements of cultural collections. If you are not sure how to choose a service provider, always contact a conservator or preservation professional for advice.

### Summary

Spores, active or dormant, are ubiquitous. Although it is impossible to get rid of all the spores, mold growth can be controlled. Most important for mold control is maintaining RH conditions below 55%, or, better, below 45%. Use of protective enclosures, meticulous housekeeping, monitoring of RH and temperature, and a watchful eye are also important. If resources allow, high-level filtration of storage areas, if not of the whole building, is recommended. Protecting library and archival collections from water accidents should be among the highest priorities for any institution. Wet collections must be immediately dried or stabilized by freezing. Moldy materials must be isolated, dried if wet, then cleaned using the strictest precautions.

### Further Reading

Chamberlain, William R. "A New Approach to Treating Fungus in Small Libraries." *Abbey Newsletter* 15.7 (November 1991): 109.

- A practical article describing the response to a mold outbreak and the preventive measures that were subsequently undertaken at the Virginia State Library. Available online at <http://palimpsest.stanford.edu/byorg/abbey/>.

"Mold As a Threat to Human Health." *Abbey Newsletter* 18.6, (Oct 1994).

- A short article on mold as a workplace hazard for library and archival workers. Summarizes articles relevant to the subject and anecdotes from the field. Available online at <http://palimpsest.stanford.edu/byorg/abbey/>.

Nyberg, Sandra. *Invasion of the Giant Spore*. SOLINET Preservation Program Leaflet Number 5 (Atlanta, GA: Southeastern Library Network, 1987), 19 pp.

- An updated version of this leaflet (emphasizing preventive activities and non-chemical treatments) is available from LYRASIS on its web page at <http://www.lyrasis.org/Preservation/Resources%20and%20Publications/Invasion%20of%20the%20Giant%20Mold%20Spore.aspx> or from Alicia Riley, Preservation Administrative Coordinator, LYRASIS, 1438 West Peachtree Street, NW, Suite 200, Atlanta, GA 30309-2955 (e-mail: [alicia.riley@lyrasis.org](mailto:alicia.riley@lyrasis.org)). The older version of the leaflet gives a good summary of mold prevention and treatment, and also presents detailed information on various chemical treatment methods that in most cases would no longer be recommended.

Price, Lois Olcott. *Managing a Mold Invasion: Guidelines for Disaster Response*. Philadelphia, PA: Conservation Center for Art and Historic Artifacts, 1996. CCAHA Technical Series No. 1.

- An excellent summary of response and recovery techniques. Includes a good bibliography that cites articles on the effects of fumigation on collections. Available from CCAHA, 264 South 23rd Street, Philadelphia, PA, 19103; (215

545-0613, fax (215) 735-9313, or e-mail [ccaha@ccaha.org](mailto:ccaha@ccaha.org).

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