



# BIOFACT MAINTENANCE AND STORAGE GUIDE

ZOOLOGICAL SOCIETY OF MILWAUKEE

DRAFTED BY JULIA COLBY AND SHANNA M. HILLARD  
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## Scope and Purpose

The goal of this document is to outline some basic principles to improve stewardship of biofacts your institution uses to interpret the natural world and educate the public. It also recognizes that many institutions have very limited budgets and staff time, and every attempt is made to give suggestions for improvements and techniques at various price points and capacity levels. Remember that while you may not be able to do everything in this document to make storage “perfect”, anything you do to improve your storage will improve the lifespan and usability of your biofacts.

## Types of Biofacts

### Bones/ Skulls/ Antlers

Skeletal materials are made of bone, which is made of protein, collagen, and minerals (largely calcium). Provided they are cleaned well (de-fleshed and degreased) they are largely stable if stored at consistent temperature and humidity. They are susceptible to acid damage, so any paper material that touches skeletal specimens should be acid-free (see Materials section).

### Teeth/ Ivory/ Tusks

Teeth are made of dentin and enamel. Because of the nature of how teeth grow they have layers that may delaminate or crack due to rapid changes in temperature or humidity.

### Horns

A keratin sheath that fits over a bony protrusion They are relatively porous and are susceptible to damage from fluctuations in temperature and humidity.

### Pelts/ skins

Tanned animal skin. If prepared correctly, probably the least susceptible to temperature/ humidity damage. There is a risk of mold if humidity is not controlled and some risk of pest damage.

### Mounts

Skin stretched over a form usually (but not always) rigid foam. Because of the 3-D nature of the specimen, they are vulnerable to damage from knocks and bumps. There is also the risk of mold and damage from pests. Depending on the age of the specimen, it may have been treated with arsenic or other pesticides.

### Dried Specimens

Insects and plants are typically preserved dry. Some smaller taxidermy pieces (small songbirds, lizards, snakes) may be created by freeze drying a whole animal. While all specimens are vulnerable to pest damage, small, freeze-dried specimens are especially vulnerable and should be stored extremely carefully. If possible, avoid adding freeze-dried specimens to your collection.

## Wet Collections

Usually used for whole body preservation of specimens that don't dry or taxidermy well (e.g. reptiles, amphibians, larger invertebrates) or body parts/ organs. May be preserved in a humectant (often a proprietary fluid like Nasco-Guard™ or CaroSafe™) alcohol (ethanol or isopropyl), or formaldehyde or formalin. It is important to keep specimens in fluid from drying out (which will ruin them), and it's very important to record what fluid they are stored in. Future you (and everyone who deals with your collection after you) will thank you for your diligence!

## Environmental Considerations

The environment in which biofacts are stored is one of the biggest contributors to how long they last. Annoyingly, the environment is also the hardest part to control. Creating a microclimate (a cabinet or a box) is the best way to manage the environment in cases where the whole space cannot be conditioned or altered.

## Light

Light damage is cumulative and irreversible and may contribute to bleaching, fading, or other damage. When possible, store biofacts (especially brightly colored ones, like bird mounts/ feathers) away from natural light. Fluorescent lights do emit low levels of UV light (the part of the spectrum that is most damaging), and limiting specimen exposure to these lights is beneficial over the long run, but not as critical as limiting natural daylight.

## Temperature

The ideal biofact storage temperature is between 55-59F for maximum longevity. However, in most situations, this is impractical from both an HVAC and a human comfort perspective. A higher temperature range (65-70F) is well within the range of what the specimens can tolerate. Consistency in temperature is important- it's far better to be 80F year-round than bouncing between 60-70F daily or 65-90F seasonally. Creating a microclimate using a box or cabinet will help mitigate temperature swings. **Temperature is inversely correlated to humidity- so the lower the temperature the higher the humidity will be and vice versa. Controlling the temperature in the space can help you reach optimal humidity, or tame swings in the RH of the room.**

## Relative humidity

The ideal relative humidity (water vapor in the air relative to the ambient temperature) for storing biofacts is between 30%-65% RH. Below 30% RH increases the risk of specimens becoming brittle (embrittlement), and above 65% increases the risk of mold growing on organic materials. However, maintaining consistent RH in storage is maybe more important as storage within the target range- storage at a consistent 70% relative humidity (despite being out of the target range) is far better than storage where the RH fluctuates rapidly between 40%-60%. Large fluctuations increase the risk of tears/ rips in skins and



taxidermy specimens and cracking on teeth, bones, and other osteological materials. Maintaining a constant RH is often much more achievable on a budget.

Inexpensive Temperature and RH monitors are available online or locally at hardware or big box stores. If possible, obtain a digital one that will record data and synthesize it in a graphical format to help you track temperature and humidity shifts (See Figure 1, below).

It's ideal to have more than one temperature/ humidity monitor in a space- initially, you might want to take readings from the larger room and have data from whatever storage structure you are using (shelves, cabinets, etc.) Once you have this data, you can determine what, if any, changes you need to make.

## Storing Wet Collections

This section is written assuming you are storing wet specimens totaling less than 25 gallons of flammable liquids (ethanol, formaldehyde, or formalin (a dilute formaldehyde solution) OR have a wet collection that is stored in a proprietary humectant like Nasco-Guard<sup>®</sup> or CaroSafe<sup>®</sup>.

### *Storage Considerations.*

Wet collections benefit from the temperature and humidity storage conditions that suit other biofacts- again, with the caveat that storage in consistent conditions that are out of the ideal range is better than wildly fluctuating conditions that are in the ideal range. Specimens should be stored securely on shelves or in cabinets- if the shelves are open, a bar or rod should be threaded around the edges to ensure that the jars cannot vibrate off the shelf. Monitor jars for leakage, especially during transport. Universal absorbent pads (available at auto part supply stores, online, and big box hardware stores) are excellent additions to boxes used for storage and transport in case anything leaks. You may also store liquid specimens [in a flammables cabinet](#). Be careful to not exceed the liquid limit for the cabinet and install it according to the manufacturer's instructions.



## Modifying the Environment & Creating a Microclimate

Once you have data about temperature and humidity in your storage space, you may need to further modify the climate to ensure proper storage by creating a small, easily controlled space in a cabinet or a box (a microclimate) or modify the space by removing additional water from the environment with a dehumidifier.

Problem Identified	Possible Fix	Notes
Humidity Too High (above 70%)	Raise temperature; use dehumidifier	Dehumidifier introduces water to the storage environment- may need to be emptied by hand.
Humidity Fluctuates	Move open shelving into cabinets	Monitor cabinets to see how RH changes inside.
Humidity Fluctuates	Shroud open cabinets	See below for details. Monitor after shrouding to see how RH changes.
Humidity Fluctuates	Move specimens to boxes	Monitor the inside of boxes to see how the environment differs from ambient. See “storage materials” for more details on boxes

### Dehumidifiers

Humidity in a closed space can be adjusted by purchasing a dehumidifier. Before selecting a dehumidifier, you will want to know the size and humidity levels of the space. Humidity can be measured by purchasing the humidity monitors mentioned above and tracking the humidity levels over a set period of time. This will help you decide what size tank you will need. For example, a room under 1500 square feet that experiences a moderate amount of humidity will need a tank with a minimum of 20-pint capacity. Once you have these pieces of information, you need to think about the following additional factors:

1. **Budget:** How much money can you spend on this piece of equipment?
2. **Location:** Is your storage space above or below ground? Are there doors/windows to the outside that are being opened constantly?
3. **Drainage:** Do you have access to a floor drain in your storage space or hookups for a pump?
4. **Staffing:** Who will maintain and/or empty the reservoir and clean the air filter and how often will they be able to do this?
5. **Access:** How accessible is the storage location in your daily work? On or offsite? In one building or spread across several buildings?

Taking all of these factors into consideration will help you select the best dehumidifier for your space. For instance, if you have your collection spread across several buildings, it might not be economically feasible to purchase several workhorse dehumidifiers. If you don't have staff to empty the dehumidifier consistently, try finding one that will allow you to use a floor drain or a pump system. Below is a chart with all the factors included here and some recommendations based on

the Zoological Society of Milwaukee’s experience with dehumidifiers combined with some research done by The Spruce.

Recommendation	Space	Budget	Location	Drainage	Staffing	Access
<a href="#"><u>Honeywell 30-Pint Smart Dehumidifier</u></a>	1000 sq ft or under	\$279.00	Any	Floor Drain or Manual	Air filter cleaning and manual emptying if no floor drain No pump available	Comes with an app that allows you to adjust remotely.
<a href="#"><u>Whynter Energy Star Portable Dehumidifier with Pump</u></a>	1000-4000 sq feet	\$249.00	Best for large storage areas or basement storage	Floor Drain, Internal pump, comes with drainage hose	Filter cleaning every two weeks, largely hands-off with drainage	Manual use requires bucket to be frequently emptied, very accessible
<a href="#"><u>Homelabs Dehumidifier with Wi-Fi</u></a>	1500 sq ft or less	\$189.00	Any, but great for office storage spaces and spaces without drains	Floor Drain or Manual	Wi-Fi-enabled, notifies you when full, can adjust from app.	On wheels, tank removes easily, app for remote access

### Shrouding Open Cabinets

Adding a plastic cover to an open cabinet is an easy and economical way to build a microclimate that is more suitable for storage than the ambient environment.

Plastic construction film made of polyethylene (sometimes sold under the brand name Visqueen<sup>®</sup>) is a good material for this task as it is economical, easy to obtain, and inert - the plastic will not break down over time. The material comes in a variety of thicknesses, measured in mils. A

thickness of four mils will make a durable barrier .Another inexpensive option, especially for single shelving units is shower curtains- just be sure to check the composition of the plastic prior to purchase. Do not use PVC sheeting or shower curtains.

Attach the sheeting to the shelving unit, covering the sides (if open), and the front. For wooden shelving, you can staple the sheeting directly to the shelving. For metal shelves, use magnets to attach the sheeting to the shelving- you can use a hair straightener to make little magnet pouches to make the front flap (the door) easier to open without losing all the magnets.

In addition to mitigating humidity swings, the sheeting has the added advantage of preventing water penetration in the event of flooding or leaking ceilings.

## Boxes

For small objects, especially ones that are fragile, frequently used, light sensitive, or vulnerable to damage from temperature or humidity fluctuations, a simple solution is to store the specimen in a box. You can use pre-made boxes (see storage materials sections) with or without gaskets or make one from chloroplast. Boxes are also great for specimen transport. See Box- making section for more information.

## Jars for Fluid Specimens

When storing specimens in fluids, use glass jars with threaded, thermoplastic polypropylene lids, or polypropylene containers with threaded polypropylene lids. You may be able to find these on the internet, through a lab/ medical supply company, or a bottling supply company. Other plastics can be easily damaged or may melt when exposed to either ethanol or formalin. Specimens purchased commercially should be stored in the appropriate type of container. In a pinch, a glass jar with a metal lid (such as a reused food jar) can be used for short-term storage. The metal lid will corrode when exposed to most preservation chemicals, so plans to re-house these jars should be made as soon as possible.

## Storage Materials & Techniques

Here is a guide to common materials/ scenarios where you may need to make choices about what materials you use to store or transport biofacts. Our goal with this chart is to illustrate where you can make easy improvements to your biofact storage, one material at a time.

Material:	Avoid If You Can:	When You Can Upgrade, Use:
Plastics (Padding)	Polyvinyl chloride (PVC), urethane foams, polystyrene foams (Styrofoam). Note: these do have utility for short-term use but should NOT be used for long-term storage mounts.	Polyethylene (PE) expanded bubble sheets (aka Bubble wrap™); Ethafoam sheets/ planks,

		Plastazote™, Volara™,  Note: These are brand names and generic versions are available; just check the materials
Plastics (boxes)	Polystyrene, PVC boxes	Polyethylene (often listed as HDPE); acrylic (mostly used in display cases)
Fabrics (for covers for specimens or mounts)	Synthetic fabrics (polyester, rayon)	Undyed, unbleached cotton muslin
Packing peanuts (for cushioning skulls, mounts, bones, etc. for movement)	Biodegradable packing peanuts- Note: these are made of expanded cornstarch and are eaten by insects that will also eat your collections. These should be avoided if at all practical.	Polystyrene packing peanuts. While not one of the “favored” plastics, they do not pose the significant risk of pest damage that biodegradable peanuts do. Don’t use it for long- term storage
Tissue paper- for wrapping specimens, or long-term storage	Gift tissue paper	Uncolored, acid-free tissue paper
Cardboard (for storage, boxes)	Regular cardboard	Acid-free cardboard or matting board; corrugated plastic (Chloroplast, see Box Making)
Material/ Use	Avoid, if possible	Better choice
Paper for labeling dry material (or any paper that you want to have in long-term contact with a Biofact)	Printer paper; newspaper, newsprint, any kind of tape	Acid-free paper (look for the infinity mark or designation of “Permanent Paper” on the packaging.
Writing tools for labels (Dry)	Ballpoint pens, pencils, Sharpie-type markers (note: sharpie® does occasionally produce archival writing tools, however as of writing this	Carbon-based pigments such as Sakura Pigma Pens, India Ink, Pigment Liners by Staedtler

	document there do not seem to be any on the market), other alcohol or oil-based marker	
Handwritten storage labels for wet specimens	External label, taped onto the jar OR Internal label written in ballpoint pen or Sharpie- type -marker	Internal label. Use rag content paper above, printed (see section below) or handwritten with carbon-based pigment such as Sakura Pigma Pens, India Ink, Pigment Liners by Staedtler, or pencil
Tubes for Feather storage or wrapping pelts on	Plain paper towel or mailing tube	Plain paper towel or mailing tube lined (or covered) with acid-free tissue
Bags	Grocery plastic bags- do not use for long-term storage	Polyethylene bags

## Labeling

There's nothing quite as annoying as opening a box in education storage only to find it filled with unidentified biofact material. While the educators and educational programs at an institution may change, being easily able to tell what kind of skull you've just pulled out of storage is a timeless gift you can give yourselves and your colleagues.

What gets put on the label is individual to an organization and its needs, but could include:

- Species/ common name
- Name of animal (if from a zoo)
- Can it be handled by the public?
- Arsenic test status
- Date Acquired
- Inventory number
- Type of fluid used for storage

## Drop Tags

Any acid free stock can be made into a drop tag [Insert Image]; use either an archival pen (see chart above) or marker or run it through the printer to make a label. They can be attached to specimens with string (look for a cotton string that is undyed/ uncolored), small zip tie, or sewn on pelts or skins if the biofact is robust enough. The label should be durable enough to withstand handling, and big enough to contain data but not so big that it's in the way. An annoying label is a label that gets removed/ lost. Drop tags are most effectively used on specimens like mounts or objects where the texture prevents them from being permanently labeled with ink (such as corals, articulated skeletons, etc.)



## Permanent Labeling

Sometimes it is useful to label a specimen directly (usually for pelts, bones, horns, and teeth) with permanent ink. The best option is carbon-based ink (see materials table for options). If possible, avoid Sharpies<sup>®</sup> or other alcohol or oil-based inks. When labeling materials in this manner, choose an area that will not cover any crucial structures that you might want to interpret, but do not make the label so obscure that you cannot find the label. For robust pelts that are in good condition, labels can be sewn onto the underside of the pelt, if desired.

## Fluid Labels

The best specimen labels for wet specimens are internal to the jar. You can produce labels by handwriting with carbon-based ink (see chart above), or pencil. Labels can also be produced on normal office printers (inkjet printers are best, but laser printers will also work). Good quality (100% cotton) paper is best to use here. Once printed, label papers should be left to dry completely, and then reheated, either with an iron or in the microwave for 30-45 seconds to ensure the lettering is completely bonded onto the paper. Do yourself (and everyone who comes after you) a favor and include the preservative on the label. You can also produce labels by handwriting with carbon-based ink (see chart above), or pencil.

## References/ Further Reading/Works Cited

Some of these references are technical and written for a museum setting where the goal is the preservation of specimens rather than use for interpretation. However, they provide a more in-depth rationale behind many of the recommendations in this guide.

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