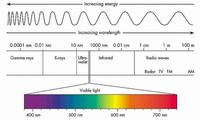
<http://www.amnh.org/our-research/natural-science-collections-conservation/general-conservation/preventive-conservation/light-ultraviolet-and-infrared>

# Light, Ultraviolet, and Infrared

**General information on light and collections**

Light (also referred to in professional literature as radiation) is best thought of as a spectrum consisting of ultraviolet light (UV) at the short end, visible light in the center, and infrared (IR) wavelengths at the long end.



UV Light

UV light is measured in microwatts of ultraviolet radiation per lumen of visible light (µW/l).  The high energy of UV radiation is particularly damaging to artifacts.  UV light is not visible to the human eye and therefore removing it from museum lighting causes no change in appearance.  Daylight is generally the strongest source of UV light; fluorescent, metal halide and mercury vapor lights also emit UV radiation.  UV light can be measured using a UV meter.  Ideally UV light should be as close to zero µW/l as possible, and light sources emitting UV measurements above 75 µW/l should be reduced.

Visible Light

Visible light is, of course, necessary in museum environments.  The standards that have evolved in the preservation community recognize that levels of light must be high enough to allow for appropriate work environments in storage and adequately view artifacts on display, but anything more than that causes unnecessary damage and should be limited.  Visible light levels are measured in lux (lumens per square meter) or footcandles (fc).  One footcandle is slightly more than 10 lux.   Visible light levels can be measured using a light meter.

Commonly recommended acceptable levels of light required for viewing museum artifacts on exhibition, based on experience and a number of studies, are given below.  The underlying logic behind these numbers is that any level of light in excess of the minimum amount necessary to adequately view an object on exhibition causes unjustifiable damage.

|  |  |
| --- | --- |
| **Levels of Susceptibility to Light Damage & Types of Materials** | **Recommended Levels of Illuminance** |
| Category 1:  Most Susceptible  e.g. textiles, cotton, wool, silk and other natural fibers, most paper-based materials, watercolors, fugitive photographic images, most organic-based natural history specimens, fugitive dyes, watercolors, some minerals. | 50 lux  (5 foot-candles) |
| Category 2:  Susceptible  e.g. high quality paper with light stable inks such as carbon black, modern black and white gelatin silver photographs, textiles with stable dyes. | 100 lux  (10 foot-candles) |
| Category 3:  Moderately Susceptible  e.g., oil and tempera paintings, bone, ivory, wood finishes, leather, some plastics. | 200 lux  (20 foot-candles) |
| Category 4: Least Susceptible  Least susceptible displayed materials: metal, stone, glass, ceramic, most minerals and inorganic natural history specimens. | Dependent upon exhibition needs |

Infrared Light

When absorbed, infrared (IR) radiation causes a rise in temperature.  IR light is also beyond the detection of the human eye.  The effects of heat on collections are covered more specifically in the section on temperatures but it is important to recognize that light radiation acts as a catalyst in the oxidation of materials – particularly organic artifacts.

Light Damage

Light damage, which is cumulative and irreversible, is a function of light intensity (in lux or footcandles) times length of exposure.  Lights that may be set at low levels but are on 24 hours a day will cause the same amount of damage as higher light levels over a shorter period of time.

For example, artifacts exhibited with 50 lux of light which is kept on for 24 hours will receive the same amount of light damage (50 x 24 = 1200) as artifacts exhibited at 200 lux where the light is on for only 6 hours when the exhibition is open to the public (200 x 6 = 1200).  Reducing the effect of light damage can be accomplished by lowering overall lighting levels, as well as by reducing the amount of time that exhibits are lit.

The most commonly seen type of light damage is fading of pigments or dyes, but light damage also manifests in other visible forms such as color shifts and in some cases darkening.  In addition there are unseen chemical changes, such as cross-linking of coatings and the physical breakdown or embrittlement of organic materials.

This blackfooted ferret mount experienced significant fading after 70+ years on display inside a diorama. It was recolored during the **[renovation of the Bernard Family Hall of North American Mammals.](http://www.amnh.org/exhibitions/permanent-exhibitions/mammal-halls/bernard-family-hall-of-north-american-mammals" \t "_self)**

Controlling Light and UV Exposure

Different types, sources and levels of light will be necessary in different parts of a museum environment.  For example, storage environments require light levels high enough for curatorial work to be conducted but there is no need for daylight, and lights should be off when not in use.  In some areas of a museum daylight might be used to create a desired effect, and as a result steps should be taken to minimize potential damage. For those spaces, objects less susceptible to light damage should be chosen for exhibition.

Lighting within museum exhibition spaces may be divided into two general categories: ambient lighting of the overall space and task lighting of the artifacts.  Again, different types of light fixtures may be combined, or if absolutely necessary, a mixture of daylight and artificial light.

Methods for reducing total light exposure include:

* Window shades, films and filters
* Decreasing the number of light fixtures
* Decreasing the wattage of bulbs
* Using light dimmers, viewer activated switches or motion sensors
* Rotating artifacts on and off exhibit

Methods for eliminating UV light include:

* Eliminating daylight
* **[Using UV absorbing plastic on windows.](http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCUQFjAB&url=http%3A%2F%2Fwww.cr.nps.gov%2Fmuseum%2Fpublications%2Fconserveogram%2Fuvfilms3-10.pdf&ei=JgDEU--cAs3KsQS75IHQCw&usg=AFQjCNFrJn8FyHuY2w7kYtSa7OIDefkSdQ&bvm=bv.70810081,d.cWc" \t "_blank)**  This type of plastic can be purchased as thin films (acetate) that can be cut to shape and adhered to the glass or as thick sheets (e.g. Plexiglas) that can be used as a secondary glazing on windows (or sometimes in place of existing glass).  A large sheet that completely covers the entire glass can be hung and attached to the inside of the window frame.
* Applying UV absorbent varnishes to window glass.  This should only be done by an experienced contractor as the varnishes when applied poorly are ineffective and aesthetically undesirable.
* Using low UV output light fixtures
* Using UV filtering shields and sleeves (available as thin plastic sleeves or hard plastic tubes) for fluorescent fixtures.  Both should be properly sized to cover the entire light fixture and must be reaffixed when light bulbs are changed.
* White paint containing titanium dioxide can be applied to window surfaces.  This method is not as effective as others but can be cost effective and simple in areas like storage where the aesthetics are less important concerns.

There is a dearth of research on exactly how long most UV filtering plastics, films and varnishes will maintain their efficacy, but information from suppliers suggest anywhere from 5-15 years. **[Research done by the Canadian Conservation Institute (CCI) suggests that 10 years](http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/2-1-eng.aspx" \t "_blank)** should be considered a general lifespan for UV filtering plastics and films.  UV levels should be checked periodically to assess the efficacy of these materials.

**Material Specific**

Light and Invertebrate Zoology Collections

The pigmentation, sheen and iridescence of entomology specimens are extremely sensitive to light.  This is also true of fluid preserved specimens where light, particularly in the ultraviolet range, enhances degradation and discoloration of fluid and specimen by accelerating oxidation processes. Specimens should never be placed in direct sunlight and it should be recognized that glass (of either specimen jars or specimen cases) does not filter ultraviolet light in the 300–400 nm range, which is the most damaging to specimens.  Additionally, sunlight can lead to increased temperatures (for more see temperature and RH)

As an example of light damage to dry invertebrate collections, consider how UV light in combination with other environmental factors plays a significant role in the deterioration of amber. Excessive light exposure can lead to darkening, crazing (network of fine cracks on the surface) and fracturing, which can compromise or even prevent examination of inclusions.

Amber specimens that have darkened or crazed as a result of light exposure and other environmental damages.

For more on preserving invertebrate zoology collections click here.

Light and Vertebrate Zoology Collections

Vertebrate zoology collections are highly susceptible to light damage.  Fading, discoloration, loss of pigment, embrittlement and chemical breakdown is a real danger with these organic based collections.  Controlling light levels should be a priority for vertebrate zoology collections in storage and on display.  Ideally skin, fur and feathers should not be subjected to light levels above 50 lux (5 foot candles) for extended periods of time.

Alaskan Brown Bear from the Bernard Family Hall of North American Mammals,**[before and after recoloring](http://www.amnh.org/explore/amnh.tv/(watch)/restoring-the-hall-of-north-american-mammals/recoloring-the-animals-in-the-dioramas/(category)/42948/(p)/1" \t "_blank)**.

More information on preserving vertebrate zoology collections can be found here.

Light and Paleontology Collections

Most fossil specimens are not directly affected by either visible or ultraviolet light, but other mineral components of a collection can fade, change color, decompose, or change phase in response to high light levels. A bigger concern for paleontology collections is the ability of light to affect adhesives and consolidants used in the preparation or preservation of a specimen, as well as its effect on other collection housing materials.  “Sub-fossil material, such as horn sheaths or complete mummified carcasses, is especially sensitive to light” (Collins, 1995, p.119).

More information on preserving paleontology collections can be found here.

Light and Physical Sciences Collections

As with paleontological collections, you might think that mineral specimens are impervious to light damage.  While this may be true for most of the thousands of mineral species, a number can have interesting and complicated reactions to visible, ultraviolet and infra-red light.  In the example below, a realgar specimen on extended display has converted to pararealgar as a result of light exposure and other non-ideal environmental conditions.

Realgar (red) transforming into pararealgar (orange-yellow powder).

More information on preserving physical sciences can be found here [link to collection specific challenges section]

**Additional Resources**

**[Canadian Conservation Institute Notes](http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/index-eng.aspx" \t "_blank)** offer practical advice about issues and questions related to the care, handling, and storage of cultural objects. Relevant Notes include:

* **[N2/1 Ultraviolet Filters](http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/2-1-eng.aspx" \t "_blank)**
* **[N2/3 Track Lighting](http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/2-3-eng.aspx" \t "_blank)**
* **[CCI Environmental Monitoring Equipment Loans Program](http://www.cci-icc.gc.ca/services/equip/equipbro-instbro-eng.aspx" \t "_blank)**