18. Parchment Treatments

Definition of Terms

Parchment is typically described as a highly stressed sheet material with a stiff handle which is made from the skins of small domesticated animals such as calves, sheep and goats, that are cleaned of their hair and flesh and then dried under tension on a frame. Vellum, which derives from the Latin word vitulus and the French word veau for calf, was often used to describe a very fine quality of parchment which was preferred for painting and illumination. However, the two words were often used interchangeably in the past, and even sometimes in combination with each other, without any clear distinction between animal type or method of preparation. Since parchment is presently the term preferred by a large number of conservators, scientists and scholars, working both in the U.S. and abroad, it has therefore been adopted for use in this chapter of the Paper Conservation Catalog.

18.1 Purpose

Although parchment exists in many different formats the emphasis of this chapter will be on the conservation of unbound parchment artifacts, including prints, drawings, manuscripts, maps, documents, and single book pages. (Parchment books and bindings present certain unique problems which are beyond the scope of this chapter.) Many conservation problems of parchment are similar to those of paper, and there are many similarities between their treatment solutions. However, since parchment is completely different from paper in nature, origin, and behavior, some treatment procedures are used which would not be suitable for paper, and some common paper treatments, such as aqueous immersion, are destructive to parchment. (See AIC/BPG/PCC 4.4.6. C. Support Problems: Parchment/Vellum.) Among those who are accustomed to treating parchment, there are many differences of opinion about what methods are effective or acceptable. This chapter describes a range of treatments currently in use, with an emphasis on unbound materials. Also included are treatments with a history of use, but not necessarily recommended now for a variety of reasons. Arguments against the use of these outdated treatments have been included.

18.2. Factors to Consider

18.2.1 Identification of Parchment

A. Reasons for Identification: There are many reasons why the conservator would want to proceed with the following methods of identification before initiating a particular treatment. Most importantly, one would want to confirm that the artifact is, in fact, made from parchment (instead of paper or any other material) so that the appropriate method of treatment is chosen. It is also helpful to know the animal type from which the parchment is made, and certain aspects about its method of manufacture, so that one will be able to anticipate how the skin will react under specific treatment procedures. For example, if the parchment proves to be made from sheepskin, and if it is a modern flesh split rather than a skin with an intact grain layer, the conservator would know in advance to use caution in certain drying, mending and mounting procedures that might put undue tension on such an inherently weak type of parchment.

Although it may not always be appropriate, given the nature of the treatment and the expectations of the custodian, certain techniques of identification may be

pursued as a means of determining the origin and provenance of a parchment artifact.

B. Means of Identification

1. Visual

The characteristic features of parchment, which confirm its animal origin, can usually be recognized under close examination with a hand lens or a microscope. These features include the follicle pattern, veining, natural scars and bruises, and fat deposits in certain skins. Often the follicle pattern is more pronounced across bony areas of the animal, such as along the ribs and spine, and depending on the species the hair follicles may be spaced closer together in these areas than elsewhere. The irregular edges of a parchment sheet may reflect the outer perimeters of a skin, where a natural curve follows the outline of the animal's leg. Particularly stiff and horny areas in a given sheet may represent the outer ends of the skin, shoulders or butt, whereas weaker, more fleshy areas usually come from the axillae (armpit) and belly of the animal.(Many of these features are more thoroughly described and illustrated in Cains 1992.)

Raking, transmitted, and ultraviolet light often help to make these features more prominent. Ultraviolet light in particular often shows fluorescence of natural fats in the skin, as well as other processing substances, although the reliability of the technique is uncertain. It has, however, proved useful in the identification of tannins which were applied to the surface of early Jewish parchments such as the Dead Sea Scrolls. (Reed 1972.)

2. Analytical

Analytical methods of examination usually rely on samples that are taken from the artifact. Cross-sections of parchment can be examined under the light microscope and with scanning electron microscopy (SEM). The identification of protein using the biuret test can be performed on a sample; however, in using this test, one cannot distinguish between real parchment and a paper that was heavily sized with gelatin (see AIC/BPG/PCC 10. Spot Tests). In that situation, other methods of analysis are recommended. If a very small sliver of sample can be taken, a simple flame test on true parchment will result in the pungent odor of burnt protein. This test requires no expensive analytical equipment or lab.

Fourier Transform Infrared Spectroscopy (FTIR) analysis can be used to non-destructively differentiate between parchment (protein) and paper (cellulose) even when the paper has been heavily sized with a protein size. A paper coated on both sides would be distinguished by a higher proportion of calcium or other opaque white pigment. (Certain types of parchment documents and most parchment book covers were heavily dressed with chalk on the flesh side and would therefore give high calcium readings with FTIR analysis. It is more unlikely, however, for these objects to be mistaken for paper during visual examination.)

Scanning Electron Microscopy/Energy Dispersion Spectroscopy (SEM/EDS) analysis has been used to compare old and new parchment skin. In particular, levels of chlorine (possibly used as a disinfectant) appeared to be higher in some

new 20th century samples than in older (18th and 19th century) parchment.(DvdR)

C. **Distinguishing Parchment from Paper** (see also 18.6.1 Special Considerations.)

During simple visual examination it is often very difficult to distinguish certain types of parchment (usually flesh splits from the 19th/20th centuries) from some highly calendared papers, often called "parchment paper" or "vellum paper" (Jenkins 1992). However, differentiation between these two materials is essential since misidentification could lead to inappropriate methods of treatment. (See Smith and Bunting 1993.)

Differentiation between some translucent papers and parchment (especially split skins) may require fiber analysis. The paper fibers are often damaged to the point where they have lost most of their morphological characteristics, but the collagen fibers of parchment should be readily identifiable. (LP)

SEM/EDS analysis has been used to compare parchment skin and parchment paper; although surface and cross-sections of parchment (tissue) and paper (fibers) are somewhat similar morphologically, elemental analysis is quite different. (DvdR)

18.2.2 Features to Record/Observe

Listed below are a series of prompts that are intended to assist the conservator in the examination of a parchment artifact prior to treatment. Since many technological features can be altered by certain treatments it is important to record their presence beforehand and to carefully consider one's treatment approach in order to ensure that these features are preserved. Damages that may have occurred to a parchment artifact over time can sometimes be confused with certain natural irregularities in the skin, or with alterations that may have been carried out during the making of the object. Distinction between these features can also be helpful prior to treatment.

A. **Technological Features**

1. Features relating to preparation by parchment maker: animal source; hair and flesh sides of the skin; spine direction of the animal as oriented on the sheet; thickness of the skin (can vary greatly across the surface of a single sheet); full thickness or split skin; surface characteristics (degree and evenness of scraping, napped or smooth, presence of surface coatings, etc.); imperfections (scars, bruises, original repairs, etc.); location and degree of cockling and/or pleating; irregularities in shape of sheet (often indicate its previous location in full animal skin).
2. Features relating to use by scribe, artist, bookbinder: pricking holes - size and shape; ruling lines - made with stylus, metalpoint or pen and ink; underdrawing - usually in thin pen lines or washes; plate marks made by printing; marginal notes/instructions by scribe; creases indicating how a parchment document was originally folded; impressions made by sewing thread in gutter of book - often still visible in intact bifolia or single manuscript leaves; sewing holes - made for attachment of fabric interleaving to illuminated manuscript leaves in bound books

B. **Features Relating to Condition of Support**

cockling, pleating, transparency, horny areas, gelatinization due to water damage (important to distinguish from naturally transparent areas); abraded areas (important to distinguish from corrections made by scribe or artist using a knife or other abrasive tool); punctures, tears and cuts (important to distinguish from cuts made intentionally by scribe or binder to flatten out natural cockling in skin); repairs (same issues involved); stains and accretions; mold damage; perforation/corrosion caused by acidic media, etc.

18.2.3 History of Manufacture and Use of Parchment

A. Overview of Manufacturing Processes, Ancient to Modern

The different historical methods of manufacturing parchment in the West are described in detail by several authors including Ronald Reed, Hedwig Saxl, Richard Johnson and Daniel Thompson. William Visscher and Benjamin Vorst, both modern-day parchment makers, provide insights into the current techniques of parchment manufacture. Since a detailed description of parchment manufacturing processes is beyond the scope of this chapter the reader is encouraged to pursue the bibliographic sources cited above.

Ancient Jewish methods of parchment manufacture usually included the application of weak tanning solutions to the skin surface, often only the surface of the hair side. This was done as a final step in the parchment making process and was perhaps intended to toughen the surface of the skin prior to writing. (See Reed 1972, M. Harran 1985, 1991). It is unclear whether a similar process was carried out in other countries, at other times. 18th and 19th century Hebrew scrolls were written on a type of parchment called "gvil" which was supposedly made using ancient manufacturing techniques, employing some type of tanning agent. However, the thickness, dark color and soft handle of these modern skins make them seem much more like leather than their earlier ancestors.

B. History of Its Use as a Support

1. Book Materials: This category includes small cuttings and other fragments, single leaves and conjoint bifolia from manuscripts and printed books that were once whole codices, and books in scroll form that had, for the cultures who made them, either religious or magical importance. (Although parchment was used to make book covers as well, issues regarding their preservation and treatment will not be addressed in this chapter.) Fragments and leaves removed from books usually contain media on both sides and may also retain evidence of their earlier function as bound codices (see 18.2.2 A for a list of the structural features that might remain in these artifacts). Parchment objects in scroll format typically contain media on only one side and are made up of multiple pieces of parchment that are joined edge to edge with adhesive or by sewing with thread, parchment thong or sinew. Depending on their date of manufacture and their country of origin parchment books were either written by hand, using iron gall or carbon inks, or printed with more resinous printing inks. They were also frequently decorated or illuminated with a variety of pigments and metals such as gold, silver, tin and their alloys.

2. Archival Parchment: This category includes a wide variety of official and private documents (contracts, deeds, wills, indentures, genealogical tables, etc.), maps, architectural drawings and garden plans. Many parchment legal documents have ribbons or ties, often with associated seals, which were laced through the folds at the bottom after they were signed in order to prevent unauthorized additions or changes. This practice sometimes obscures text or signatures but is an inherent part of the document.(LP) Parchment documents and other archival materials can be made up of a single sheet or multiple sheets; the latter are either stacked one on top of the other and joined at a single edge, or they are joined end to end to make a roll which, in many cases, would extend as much as 25 feet in length. (Membrane is the term used to describe each loose sheet of parchment used to record British official documents. The term is also used for each separate sheet of parchment forming a roll. See Guide to the Contents of the Public Record Office. vol. 1 (1963), p.206.) The sheets in these composite documents are either joined by sewing with thread, cord, ribbon, etc., or with adhesive. So as to make up the large format needed for maps, architectural plans and drawings, single sheets of parchment are often joined at the edges with adhesive to make larger supports. Routine official documents were often written in iron-gall or carbon inks, and later printed with carbon oil-based inks. Depending upon the relative importance of certain medieval documents on parchment, such as those created for a king or duke or for a wealthy religious house, they were often illuminated with various paints and gold leaf. Architectural plans and drawings from the medieval period were often executed in pen and ink, whereas maps and garden plans (which were executed on parchment up until the end of the 18th and perhaps into the 19th century) were also colored using gouache or watercolor.
3. Fine Art on Parchment: This category includes drawings, paintings and prints on single sheets of parchment that can be found in various sizes and formats. The types of media used for drawing and painting on parchment include graphite (rarely used, however), silverpoint on prepared grounds, pen and ink, pastel, charcoal, watercolor, and gouache (Watrous 1957). 16th and 17th century Dutch and Italian artists often used parchment as a painting or drawing support. It was also used extensively for portrait miniatures, before the adoption of ivory as a painting support in the 17th century. Many still lifes and flower paintings were executed on fine parchment from at least the 17th to the 19th centuries. Etchings on parchment were produced in large numbers during the 19th century as reproduction prints, especially in England and France (see Smith and Bunting 1993, and 18.6.6 Special Considerations). Parchment was also used as a printing support by many 19th century French artists such as Buhot and others.
4. Ritual or Sacred Objects: This category includes articles made for use as part of religious observance. In Judaism, they include Torah scrolls, mezuzot, tefillin kettubot, books, and Biblical scrolls. Their conservation treatment will require an under-standing of their context in Jewish life to determine the appropriateness of various treatments (Greene 1992). Certain items,

such as Torah scrolls, mezuzot and tefillin, should be given to a qualified religious scribe (soter) if it is intended they be used for religious purposes. In Islam, Korans have been written on parchment, and some Moslems feel that a Koran used for prayer should only be treated by a male Moslem. This should be discussed with a responsible custodian or curator before treatment.

18.2.4 Unique Qualities of Parchment as a Support

A. Structural Qualities

1. Physical and Chemical Stability: Parchment is usually a very strong and durable material that is quite resistant to mechanical damage such as surface abrasion, creasing and tearing. (Modern parchments made from the inner splits of sheepskins have little tear strength, however, because they lack the tightly connected fiber structure of the grain layer.) Parchment is more resistant than paper to corrosive inks and paints, yet perforation of the support can ultimately occur in the presence of moisture. Parchment is susceptible to biological attack and, in extreme circumstances, the collagen structure can be completely degraded in the presence of mold. Parchment is not as prone to acid degradation as is paper, due in part to alkaline agents such as lime and chalk that are used in the manufacturing process. (See AIC/BPG/PCC 4. Support Problems.)

2. Hygroscopicity: The extremely hygroscopic nature of parchment makes it dimensionally unstable, causing it to expand and contract in response to changes in the surrounding environment. This often leads to distortion or cockling of the sheet and other dimensional changes which can range from minor to severe, depending on the surrounding environmental conditions. Treatment goals can often be affected by the extreme reactivity of parchment to changes in relative humidity, particularly when treatments involving the use of moisture are being considered. (See 18.2.5 Potential Alteration/Damage to Objects in Treatment.) Methods used for the housing and display of parchment artifacts must also include consideration of its hygroscopic nature. (See 18.4.13 Housing, 18.4.14 Sealed Transport and/or Display Packages and 18.6.)

   Media found on parchment are often affected by the reactivity of the support to changes in relative humidity, especially in cases where the paint or ink may be brittle and/or thickly applied. The expansion and contraction of the parchment support usually occurs at a faster rate, thus putting stress on the media. If the media is unable to respond to extreme stress it will begin to crack and eventually flake off the parchment surface. These issues need to be considered when undertaking treatments involving moisture and when choosing environmental conditions for storage and display.

3. Thermal Reactivity: The effects on parchment to both dry and moist heat are important features to consider. According to Reed (1972, pp.316-318) parchment can withstand a dry oven temperature of 100°C. almost indefinitely without any obvious changes in color, dimension or shape. Once removed from the oven the skin absorbs moisture from the atmosphere and is able to regain its original handling properties. Heating

parchment at higher temperatures has a more dramatic effect, with 130-150 degrees C. being a critical temperature at which intense curling and browning occur.

Moist heat has a much more dramatic effect on parchment than dry heat. The addition of moisture causes the collagen fibers in parchment to swell and then rapidly contract. This phenomenon, which is often used to determine the relative age of a piece of parchment, is referred to as the shrinkage temperature. Ancient parchments have collagen fibers that are more degraded and hence they shrink at much lower temperatures than modern skins. (For more information on this subject see Reed 1972, pp.313-316, Haines 1987, and Young 1990 and 1992.)

B. Surface Qualities

1. Inherent to Methods of Manufacture: The surface qualities of parchment are most often determined by the methods used in fabrication of the skin. Parchment made from a full thickness skin usually has a distinct hair and flesh side while sheets that derive from split skins have a much more uniform appearance from side to side. The lack of particular surface characteristics on split skins can often make them difficult to distinguish from highly calendared papers, often known as "parchment or vellum paper." (See 18.2.1.B Means of Identification and 18.6.1 Distinguishing True Parchment from Modern Parchment and Vellum Papers.)
2. Surface Preparations and Coatings: The surfaces of a finished sheet of parchment can be prepared or coated so as to make the two sides more uniform in appearance and also more receptive to inks and paints.

   Although the work could be done by the parchment maker it was probably more often carried out by scribes or artists, or their assistants. Surface preparations can include scraping with a sharp knife, smoothing and raising a soft nap with pumice, burnishing with a stone or other hard material, and dusting with French chalk. Parchment supports would also be coated with a variety of materials for different purposes. During the medieval period Byzantine artisans would apply egg white (glaire), natural oils and other materials to the parchment and then burnish it to achieve a very smooth, highly polished surface for writing and illumination (Abt 1989, Bykova et al. 1976, Bykova 1993). Russian illustrated documents were coated with a matte white paint prior to execution.(JM) During the 19th c. parchment intended for printing could also receive a surface coating (Jenkins 1992, Smith and Bunting 1993). The particular type of surface coatings found in medieval Greek manuscripts (see above) makes the illuminations extremely susceptible to flaking, whereas the writing is rarely affected. (Although flaking would often occur relatively soon after the manuscripts were made the Greek artists never seemed to alter their technique. Instead, the miniatures would simply be painted over once the amount of paint loss was substantial enough to warrant it. AQ) In other types of medieval manuscripts, such as those produced in Italy or elsewhere by Italian craftsmen, the parchment is prepared in such a way that the hair side has a very soft, almost velvety nap while the flesh side is smooth and slick. Whether or not there was some type of surface

preparation or coating on the flesh side of these skins has not been determined. Nevertheless, in these manuscripts flaking of the media (particularly the writing ink) is much more predominant on the flesh side than on the hair side. (AQ)

C. Original Repairs, Compensation and Joins

Original repairs and compensation are usually absent in fine art on parchment (i.e., paintings, drawings and prints) because the artist only needed a single sheet for his work and was therefore able to choose one of very high quality. On the other hand, many sheets of parchment were required for a manuscript book, rolled document or large map or architectural plan. Although the craftsman might have preferred to have the skins all of fine quality, his choice was often limited to what was available or by the amount of money he was able to pay for good skins. In general, folio size manuscript books (and, by association, their detached leaves) tend to have a greater number of original repairs than much smaller manuscripts of the same type.

1. Sewn Repairs: Repairs to parchment were often done while the skin was still wet or damp, before it was dried on the frame. These types of repairs, sewn in a figure of eight pattern across the damaged area, can be recognized by the bunching up of the damp skin and the pulling on the sewing holes that would occur as the skin dried under tension (Clarkson 1992, Figs. 22, 23, 36, 37). Sewn repairs in dry skins were also carried out by the parchment maker or by the scribe at a later stage and would tend to look quite different, with the sewing holes still circular in shape and not extended (Clarkson 1992, Fig. 38). In both cases these repairs were most often done with linen thread, but sometimes silk thread or narrow strips of parchment were also employed. In cases where the available parchment sheet was of an irregular shape, due to its having been cut along the outer perimeter of the full skin, additional pieces would be attached to compensate for the irregularity. These pieces were usually secured by sewing with thread or parchment thongs. Sewing was also a common technique for the joining of multiple pieces of parchment to form a scroll. Both thread and a type of sinew or gut (in the case of Hebrew manuscripts) were used as sewing materials. (Certain types of medieval parchment documents made in scroll form often had textile or leather covers sewn onto the upper end. When the document was rolled up these covers would protect the object from damage during storage or transport.)
2. Patched Repairs: Patched repairs usually were carried out with a similar if not identical type of parchment as the original. Contemporary patches of transparent goldbeater's skin are much less common than parchment repairs although they have been recorded in some early manuscripts such as the 6th century Vienna Dioscurides (Wächter 1962, p.25). Original patches usually cover small holes that developed during the manufacturing process; it is assumed that they were attached with a collagen-based adhesive such as parchment size. Although these repairs could be performed by the parchment maker on the finished sheet, once it was removed from the frame, they were more likely to have been executed in the scribal workshop. In many cases final preparation of the surface (pumicing, chalking) would be done after the repairs were completed, thus

making the scarfed joins that much more invisible (Clarkson 1992, Figs. 33, 34).

3. Fills or Compensation: Larger pieces of parchment are sometimes used to compensate for the irregular edge of a given sheet. These patches or "fills" are applied in the same manner as smaller patched repairs, by scarfing the overlapped areas and attaching the parchment piece with adhesive. Multiple pieces of parchment would often be joined to make one very large sheet, to be used for an architectural drawing or garden plan, or for a rolled document. These pieces of parchment were connected with overlapped adhesive joins which, although perfectly functional, would not always be as precisely executed as patches or joins found in medieval manuscripts.

18.2.5 Potential Alteration/Damage to Object in Treatment

Many traditional paper conservation techniques can result in irreversible alteration of an artifact when applied to parchment. In addition, because of its animal origin, parchment can often respond to accepted treatment methods in unpredictable ways. The conservator's approach to the treatment of parchment must therefore be extremely cautious, especially if one has little or no previous experience in a particular treatment procedure. In order to avoid taking risks, and endangering the safety of the object, sometimes the best approach is little or no treatment at all. (More detailed discussions of the following hazards are found in the individual treatment sections of this chapter.)

A. **Problems Caused by Water or Excessive Moisture**: expansion of the object beyond its original dimensions; increased darkening and discoloration of skin already damaged by mold; softening and/or solubilizing of media resulting in offset onto adjacent materials (felts, blotters, etc.); alteration of surface preparations and coatings; removal of the lime and/or chalk resulting in a translucent appearance similar to rawhide; in severe cases of water exposure, realignment of the fiber bundles to a random pattern (rather than parallel to the surface) resulting in a stiff, horny, translucent skin; translucency resulting from overly damp skin being dried under no tension at all; gelatinization of an already degraded skin.

B. **Problems Caused by Excessive Pressure:** introduction of translucency/transparency in a damp skin; increased stiffness and inflexibility; reduction of printing impressions, platemarks or embossings; flattening or offsetting of media.

C. **Problems Caused by Excessive Tensioning:** expansion of object beyond original dimensions; change in platemark dimensions; weakening of media attachment; introduction of splits or tears; increase in translucency of skin.

D. **Problems Caused by Use of Heat:** irreversible contraction/shrinkage of the skin; damage to the collagen structure; alteration of surface preparations and coatings; alteration of media.

E. **Problems Caused by Use of Steam**: irreversible contraction/shrinkage of the skin; gelatinization and other damage to the collagen structure; alteration of surface preparations and coatings; weakening of media attachment; alteration or dissolving of media. (Steam is extremely dangerous and should never be used on parchment!)

F. **Problems Caused by Use of Lubricants:** alteration of surface texture and handle of skin; alteration of media (especially saturation of matte pigments); increase in

transparency and in attraction of surface dirt; change in original dimensions of object.

G. Problems Caused by Use of Organic Solvents: in discolored skins, degradation products may be solubilized with the introduction of ethanol, resulting in tide lines; alteration of media; alteration of surface preparations and coatings; possible damage to collagen structure.

H. Problems Caused by Improper Housing Methods: failure of mount due to misinterpretation of string mat or other mounting technique; failure of mount and possible damage to artifact caused by housing that does not allow for expansion and contraction of parchment; failure to support weight of pendant seals, resulting in damage; loss of friable media and damage to pulpy degraded parchment when unsuitable housings are employed.

18.3. Materials and Equipment

18.3.1 Adhesives and Consolidants (for a more complete discussion of many of the following materials see AIC/BPG/PCC 23. Consolidation/Fixing/Facing and AIC/BPG/PCC 46. Adhesives.)

A. Collagen-based Adhesives

1. Animal Hide Glue
   a. General Information: Hide glue was used heavily in the past, starting around the 16th century, for the repair of parchment manuscripts, documents, and other artifacts and for rebinding parchment codices. (See 18.4.1 Cleaning Methods.) Hide glue continues to be used today in some countries (particularly the United Kingdom) for gluing up the spines of books after sewing and for other steps in the bookbinding process.
   b. Preparation: Hide glue is prepared by soaking and then cooking in water a variety of animal waste products (usually from cows) such as skin, hooves and horns. The strained solution, which is usually caramel brown in color, can be used as is or dried into sheets or pellets. In order to remain liquid during use the adhesive must be kept warm in a double boiler. In the U.K. commercially made hide glue is often referred to as "Scotch Glue".
   c. Caveats: Since hide glue is not as pure as other collagen-based adhesives such as gelatin and parchment size it is not currently recommended for use in conservation.
2. Parchment Size
   a. General Information: Parchment size is used both as an adhesive and as a consolidant. It has a long history of use by artists and craftspeople and recipes are found in many early artists' treatises such as those written by Cennino Cennini and others.
   b. Preparation: Parchment size is made from small pieces of new parchment that are soaked overnight in distilled or deionized water and then cooked in a double boiler at approximately 50°C for about 6-8 hours, and sometimes longer. (Water may need to be added to the solution during cooking in order to counteract the effects of evaporation.) The adhesive

is decanted (sometimes strained through cheese cloth) and allowed to cool until it forms a gel. (Wächter 1982, p.164.) In some recipes the water used to soak the parchment clippings is discarded and fresh water is added for the cooking stage. (Giuffrida 1983, p.41.) This sometimes makes a weaker adhesive than when the soak water is also used for cooking.

c. Use: Parchment size is applied with a brush or, when sufficiently diluted, with a spray gun or an air brush. In some workshops ethanol or isopropanol is added to the solution in order to achieve better penetration during consolidation. If the parchment size is very viscous when the alcohol is added the solution will coagulate. It is important, therefore, to dilute the adhesive with water first before adding any alcohol. Alternatively, alcohol can be applied either by brush or spray gun in a separate step, prior to the application of the consolidant. The temperature of the parchment size also may be a factor in determining the amount of alcohol that can be added to the parchment size, and/or can affect the interaction of the parchment size with the parchment and/or pigments. Solutions of parchment size must be kept warm in a double boiler during use, in order to keep them liquid. Additives such as wine vinegar (which, when added in sufficient quantity, prevent the solution from forming a gel at room temperature) and alcohol (which aids in penetration of the media and support) have been recommended by some authors. (Reed 1972, pp.223-224, Wächter 1982, p.164.) Other materials such as flour paste, gum arabic, honey and glycerin have been added to parchment size in the past, largely in an effort to increase the flexibility of the adhesive film once dried. (Reed 1972, pp.223-224.) However the use of these additives is now discouraged because of concern about their effect on the media and the support, and the possibility of future microbial attack. (See 18.4.4.3 Consolidation of Media and 18.4.1 1 Mending and Filling.)

d. Storage: If kept in the refrigerator parchment size has a limited shelf-life. For long-term storage the liquid adhesive can be poured into thin sheets and then dried, or it can be frozen in small ice cube trays. Each time the parchment size is heated in order to make it liquid, the relative strength of the solution should be tested. Water can also evaporate during use so the viscosity of the solution may change dramatically over a period of several hours.

e. Caveats: Since a variety of chemicals are currently used in the production of parchment the conservator can never be sure of the purity of a solution that derives from modern skins. Therefore, for certain applications, it may be wiser to choose gelatin instead of parchment size if a collagen-based adhesive is desired. Parchment size is attractive to insects and mold, in conditions of high relative humidity, and it will also become brittle under excessively dry conditions. Protein films shrink upon drying. It is degraded by ultra-violet light and yellows with age. The strength of parchment size may not always be desirable, and it can sometimes be too glossy when applied as a consolidant to very matte paint surfaces. When used in a thin, warmed solution both parchment

size and gelatin will tend to penetrate the parchment skin, thus making them difficult to reverse at a later date.

Many modern parchments have been treated with formaldehyde by the manufacturer to minimize moisture reactivity, and will therefore be useless in size preparation. (PY)

Parchment size is more alkaline than gelatin due to the presence of residual lime and/or chalk in the skin. This should be taken into consideration when using parchment size for the consolidation of pH-sensitive colorants.

3. Gelatin
   a. General Information: Gelatin is used both as an adhesive and a consolidant for the conservation of parchment. Food grade gelatin is available commercially in sheet form (known as edible leaf gelatin) and also in powdered or granulated form. More highly purified pharmaceutical grade and "photographic quality" gelatins are available in granulated form from Eastman Kodak and Fisher Scientific. Gelatins are graded by viscosity in millipoises and jelly value in Bloom grams. The lower the Bloom number, the weaker the gel. (See AIC/BPG/PCC 46. Adhesives, p.43.) Solutions of gelatin are quick to prepare and the actual concentration of gelatin in solution is easily documented. For these reasons gelatin is often preferred over parchment size by many conservators.
   b. Preparation: Leaf, powdered or granulated gelatin are all prepared in a similar way by swelling the adhesive in cold water for an hour or more, and then heating it at approximately 50°C until it goes into solution. In the past, painters and restorers have used such additives as common salt, urine, calcium chloride, zinc chloride, magnesium chloride, herring brine, etc., to alter the hardening (i.e., resulting flexibility) of gelatin (see Wehlte, p.374).
   c. Use: Gelatin must be kept warm in a double boiler so that it stays liquid during use. It can be applied directly with a brush or used in a dilute form in a spray gun or air brush. In the past Anthony Cains has included additives such as sorbitol (a humectant which, in theory, keeps the adhesive flexible upon drying) and small quantities of dilute acetic acid to gelatin when it was used as an adhesive (Cains 1982/83, p.22.) However, this practice has long been discontinued by Cains because the additives seemed to have little effect; controlling the film thickness of the adhesive produced better results. (AC) In order to achieve greater penetration during consolidation treatments it is common to add either ethanol or isopropanol directly to a dilute solution of gelatin or to apply the alcohol in a separate step to the area being consolidated.
   d. Storage: Refrigeration will prolong the shelf life of a gelatin solution for approximately one month. For long-term storage liquid gelatin can be dried or frozen (see description of parchment size above), yet this is rarely done because fresh solutions are easily prepared from the commercial product.

e. Caveats: Similar to those associated with parchment size. Gelatin solutions can often be more yellow in color yet they possess a similar tack to solutions of parchment size. Gelatin solutions will tend to be more acidic (pH 4-5) and even more so if acetic acid is added.

4. Sturgeon Glue (Isinglass)

a. General Information: Sturgeon glue has a long history of use in Eastern Europe as a consolidant and an adhesive in both painting and paper conservation. In contrast to fish glue, which is made from the head, skin and bones of fish, isinglass is prepared from the inner membrane of the air or swim bladder of the sturgeon. Russian isinglass, prepared from two specific types of sturgeon, is considered to be the superior product compared to other types of isinglass. (See discussion of types of fish used to manufacture "Russian Isinglass", Alexander.) Sturgeon glue is also said to have a lower viscosity and greater tack than other collagen-based adhesives (see discussion of surface tension in Bogue 1922, p.115), such as gelatin or parchment size, and its lower gelation temperature is also advantageous in certain situations when high heat cannot be employed. Certain varieties of isinglass (yet not the Russian type) are sold by Kremer Pigments in New York and Germany and by Cornellison in London.

b. Preparation: According to Petukhova and Bonadies (1993, p.23) "Sturgeon glue is made by washing the fish bladders in hot water to remove extraneous material. The bladders are then cut open to expose the inner membrane to the air. When almost dry, the outer membrane is removed by rubbing and beating." The dried inner membrane, which is usually sold in either thick sheets or as thin, narrow strips, is allowed to soak and swell in water for several hours. The water is decanted and fresh water is added to the swollen glue in a double boiler. The glue is gently cooked at a low temperature (no greater than 60°C) until the membrane dissolves. The solution is strained if necessary prior to use.

c. Use: Although information about the use of isinglass for the conservation of parchment artifacts is not readily available, it has been recently suggested as a possible consolidant for flaking paint on parchment supports. (See Petukova and Bonadies 1993, p.29.) Since isinglass will gel upon cooling it needs to be kept warm in a double boiler during use. It is most often applied with a brush, yet can also be used in spray form for consolidation purposes. A repair tissue coated with isinglass (the manufacture of which is described by Petukhova 1989) has been recently used for semi-transparent mends on parchment (see 18.4.11 Mending and Filling). Honey has traditionally been added to solutions of isinglass for use in painting conservation, and other plasticizers such as glycerin and propylene glycol have been suggested as possible substitutes. However, the long-tern effects of these additives have not yet been thoroughly investigated. (See Petukhova and Bonadies 1993, p.24.)

d. Storage: The stock solution of isinglass can be kept for several days if refrigerated. For long-term storage solutions of isinglass can presumably

be dried or frozen, but this is usually unnecessary since the adhesive is easily prepared from the dried commercial product.

e. Caveats: The purest type of isinglass is manufactured in the former Soviet Republic and is therefore difficult to obtain in the West. It is very hygroscopic and even more so for products made from insufficiently washed raw materials that contain much sodium chloride. Sturgeon glue is also susceptible to attack by insects and mold in conditions of high relative humidity. It can also become brittle under very dry storage conditions.

B. Vegetable Adhesives

1. Flour Paste

a. General Information: Flours are made by grinding and sifting the meal of a grain, especially wheat. Although flours are made up primarily of starch, a naturally occurring polymer of glucose, they also contain brown chaff and other particles that affect the color and texture of an adhesive made from flour. Due to the low cost and easy availability of this material, among other factors, pastes made from wheat flour have been in use for centuries.

b. Preparation: Wheat flour is dissolved in water to make a slurry and then cooked at a moderate temperature, often in a double boiler, with constant stirring. Once cool the paste may or may not be strained, and it is then diluted with water for use.

c. Use: A mixture of 50/50 boiled flour paste and hide glue ("Technical Skin Gelatin"), which also contained small quantities of alum and thymol, was used for the repair of the Book of Kells in the 1950s. Flour paste has also been suggested as one of many possible additives to parchment size when used for the repair of parchment artifacts (Reed 1972, p.223). In some countries flour paste continues to be used on its own as an adhesive for repair work, and also for a particular method of tension drying on Plexiglas which is practiced largely in the United Kingdom. (See 18.4.10 Flattening/Tensioning/Drying). Wheat flour paste, buffered to a neutral pH with magnesium hydroxide, was recently selectedä over other adhesives for the repair of the 11th c. English Doomsday Book. (See Forde 1986, pp.36-37.)

d. Caveats: Flour pastes are not considered to be as pure as wheat or rice starch pastes and are therefore not currently recommended for use in conservation. Also, due to the complex make-up of flour, aged films can be very difficult to reverse with water alone.

2. Starch Paste

a. General Information: In parchment conservation wheat and rice starch pastes have been used primarily as adhesives; they are generally considered too viscous for use in consolidation. (See 18.4.11 Mending and Filling.) Starches derive from a variety of plant sources including corn, potatoes, rice and wheat, yet all are polysaccharides that are made up of two basic components: amylose and amylo-pectin. Wheat starch generally has a higher percentage of amylose (17-27%) than rice starch.

b. Preparation: Many recipes for the preparation of rice or wheat starch paste have been published in the conservation literature. In general the dry powder is soaked in water and then cooked at a moderate temperature with constant stirring. During the cooking process the granules of amylose and amylopectin swell and burst, forming a sticky paste. After cooking the paste is strained and then diluted with water for use. Wheat and rice starch are currently available from many conservation suppliers including Talas, Conservation Materials, University Products and others.

c. Use: Wheat starch paste is currently used with Japanese paper and also with new parchment for the repair of damaged parchment manuscripts and documents. It can also be used with goldbeater's skin or fish skin yet the mend is not often as strong or transparent as when gelatin or parchment size are employed. In a recent series of tests on a variety of adhesives being evaluated for use in parchment repair wheat starch paste performed very well (see Wouters et.al., 1992).

Rice starch paste is generally considered to produce a smoother and stronger but more brittle adhesive than wheat starch paste (See AIC/BPG/PCC 46. Adhesives p.10.) Although not as widely used for repair as wheat starch paste, rice starch tends to be preferred by many book conservators for certain specific applications.

d. Caveats: Starch films shrink upon drying and can continue to lose moisture and shrink over time, especially in conditions of low relative humidity. Starch films do not seem to adhere well to a smooth surfaced parchment. Aged starch films can sometimes be difficult to reverse, although this presents a greater problem when applied to a weak degraded parchment than a healthy one.

3. Vegetable Gums

Vegetable gums such as gum arabic have been suggested in the past as possible additives to parchment size when it is used as an adhesive for the repair of parchment. (See Reed 1972, pp.223-224.) Gum arabic is not currently recommended for this purpose, however, because of the increased risk of microbial attack. Despite the fact that gum arabic has historically been used as a binder for painting on parchment it has been observed to curl and peel dramatically when dry.(HS) For this and other reasons the use of gum arabic as a consolidant for flaking media on parchment is not currently recommended.

4. Cellulose Ethers

a. General Information: Cellulose ethers are made from wood pulp or cotton linters that are swollen and decrystallized using sodium hydroxide. The "alkali" cellulose undergoes etherification or methylation in order to partially substitute the hydroxyl groups on the anhydroglucose ring with alkyl or hydroxyalkyl groups such as methyl, ethyl, sodium carboxymethyl, hydroxyethyl or hydroxypropyl. After neutralization with acids the cellulose ether is further purified and then dried, milled and sifted. Cellulose ethers are produced by many companies in various

grades, viscosities and degrees of polymerization (DP). The best products are the highly purified varieties made for adhesive applications.

b. Preparation: Most cellulose ethers are soluble in cold water. Sodium carboxymethyl cellulose and hydroxyethyl cellulose are also soluble in hot water. Only hydroxy-propyl, ethyl hydroxyethyl cellulose, and ethyl cellulose are initially soluble in polar organic solvents. Although clumping usually occurs upon adding the dry powder to the solvent the cellulose ether eventually goes into solution, especially if stirred regularly.

c. Use: Cellulose ethers are generally not strong enough to be used on their own as adhesives for the repair of healthy parchment, but they often work well for the consolidation of friable or flaking media and for the consolidation and repair of weak or degraded parchment. In these situations the adhesive is usually applied with a brush. Cellulose ethers can also be mixed with other adhesives, to alter or improve their working characteristics.

Methyl Cellulose

Methyl cellulose is produced by several American and European companies under different trade names. Dow Chemical produces Methocel; Culminal, produced by Henkel in Germany, is sold in the U.S. by Process Materials or Archivart who attaches their own name to the product. A roughly 1-2% solution of methyl cellulose in water and ethanol is sometimes used as a consolidant for powdery matte paint in illuminated manuscripts (A.Q.). A methyl cellulose with a high degree of polymerization, dissolved in 80/20 methylene chloride/ methanol, has been used for ink consolidation on parchment in Italy. (See 18.4.3 Consolidation of Media.)

Hydroxypropyl cellulose

This cellulose ether is manufactured by the U.S.-based Hercules Corporation who labels their product Klucel. A 2-5% solution of Klucel-G in ethanol is used by Anthony Cains for the local sizing of degraded parchment prior to repair. (See 18.4.4 Consolidation of Degraded Parchment.) Klucel-G in ethanol is also used for media consolidation on parchment in several European countries. (See 18.4.3 Consolidation of Media) Repair tissues coated with more viscous solutions of Klucel-G or Klucel-J in ethanol have recently been used for the repair of weak, degraded parchment. (See 18.4.11 Mending and Filling.)

Methyl hydroxyethyl cellulose

This cellulose ether is made by Hoechst in Germany under the trade name of Tylose. It is widely used in Europe for both paper and parchment conservation. Tylose MH300 is currently used in Italy, either on its own or mixed with 5% Vinavil, a polyvinyl acetate emulsion, for the repair of parchment documents. Tylose MH300 was also recently selected as a suspension agent for the leafcasting of a severely damaged medieval manuscript using a purified hide powder (see Wouters, et al. 1992).

d. Storage: Cellulose ethers are remarkably resistant to mold growth, lasting months unrefrigerated, though ultimately they will attract mold growth. Refrigeration is best for the storage of cellulose ether solutions. The powder should be kept dry, in a tightly sealed container, and away from light.

e. Caveats: In a recent study by Robert Feller several cellulose ethers including hydroxypropyl cellulose did not perform well under artificial aging. (See Feller 1992.) Although methyl hydroxyethyl cellulose (Tylose) was not included in this particular study, tests in 1984 showed that it yellowed only slightly under artificial aging conditions. (See AIC/BPG/PCC 46. Adhesives, p.33.)

5. Cellulose Acetate

a. General Information: Cellulose acetate is made by the acetylation of cellulose from either cotton linters or purified wood pulps. Acetic acid and a catalyst such as sulfuric acid are used for the acetylation process, which produces a triacetate. The triacetate is hydrolyzed to remove some of the acetyl groups. Hydrolysis is stopped by the further addition of water to the mixture. The acetate is purified by washing and the cellulose acetate flakes are then centrifuged and dried. Two very similar cellulose acetate products, called Cellon and Cellit respectively, were manufactured in Germany at the turn of the century. In the case of 'Cellit' the adhesive was sold in liquid form, dissolved in ether. Kodak #4655 and Celanese P911 are two brands of cellulose acetate flakes that are currently used in conservation.

b. Preparation: Cellulose acetate is soluble in acetone, ethyl acetate and methyl ethyl ketone (MEK). For consolidation purposes it is usually made up in 2 or 3% solutions.

c. Use: Up until the late 1930's both Cellon and Cellit were used in many European libraries and archives for strengthening paper and parchment documents and for varnishing wax seals. The liquid cellulose acetate was applied with a brush to one side of a document, where it formed a protective varnish coating upon hardening. Cellon or Cellit were considered superior to the cellulose nitrate product Zapon (see below), primarily because it seemed to form a thinner film on the surface of the document to which it was applied. (See Smith 1938, pp.66-67.) Currently, the primary use of cellulose acetate is for the consolidation of flaking media on paper (not parchment) supports. However, a solution of cellulose acetate in acetone has been used for the past 20-25 years at the British Library for the consolidation of flaking paint and loose gesso in parchment manuscripts. (See 18.4.3 Consolidation of Media.)

d. Caveats: Due to their poor aging characteristics cellulose acetate products are not recommended for use in conservation. When used for the strengthening of paper and parchment documents earlier in this century the two cellulose acetate products, Cellon and Cellit, were criticized for the streaks and brownish discoloration that they created. (See Smith 1938, p.67.) Cellulose acetate breaks down creating acetic acid as one of the byproducts which, in significant quantity, would be damaging to a

parchment support. The solvents that are needed to dissolve cellulose acetate can also present a problem in its application as a consolidant. Acetone, ethyl acetate and MEK all evaporate very quickly and prevent the adhesive from penetrating into the media being consolidated. Sometimes the cellulose acetate will dry on the brush before it ever reaches the area being treated. In other cases a film of adhesive will be deposited on the paint surface. To counteract these problems the method of application may have to be modified and it may be necessary to later flush the treated area with acetone or MEK, in order to eliminate the shiny deposit left on the surface of the ink or paint.

6. Cellulose Nitrate

   a. General Information: Cellulose nitrate is formed by the reaction of cellulose from cotton linters or wood pulp with mixtures of nitric and sulfuric acids. In varying the strength of the acids, temperature, time of reaction and acid/cellulose ratio many different products with a wide range of chemical characteristics are obtained. Cellulose nitrate was first formulated in 1832 and, in 1864, the process of making a plastic from this material was patented in England. A cellulose nitrate product called Zapon was developed in Germany in the 1890's and was initially used as a paper strengthener for military maps. (See AIC/BPG/PCC 46 Adhesives pp.38-40.) Soon after this period, and up until the late 1930s, Zapon was used in many European libraries and archives for the strengthening or consolidation of manuscripts and documents on both paper and parchment supports.

   b. Preparation: The raw product, which takes the form of a yellowish-white matted mass of filaments (similar in appearance to raw cotton), was usually dissolved in a solution of acetone and amyl acetate. Recipes for cellulose nitrate as used in library conservation often included a small amount of camphor (see Smith 1938, p.54) or vegetable oil as a plasticizer. Sometimes a petroleum distillate was added to slow down the evaporation rate of the solution (see Pederson 1986, p.128).

   c. Use: The German-made product called Zapon was first recommended for use in library and archives conservation at an inter-national conference held in St. Gall, Switzerland in 1898. In the case of paper and parchment documents the liquid cellulose nitrate adhesive was usually applied to one side of the artifact with a brush. The document was then hung up to air dry for about two hours until the film hardened on the surface. (See Smith 1938, p.54.)

   d. Caveats: Cellulose nitrate is a highly unstable product that will decompose rapidly when exposed to moderate air, heat and moisture. Exposure to strong sunlight will cause cellulose nitrate to become acidic, forming a variety of acids and other materials which can damage both the media and the support. Paper and parchment artifacts that have been treated with cellulose nitrate appear cockled and brittle and, in many cases, the ink has bled as a result of the treatment. (See Smith 1938.) For obvious reasons, cellulose nitrate is no longer recommended for use in conservation.

C. Natural Resins and Waxes

Beeswax has been used in the past for the consolidation of flaking media in parchment manuscripts. (Marconi 1962.) The use of wax for media consolidation has been rejected by more recent authors due to the alteration that it causes in the appearance of certain pigments (Giuffrida 1983). Wax can also attract dust and dirt to surfaces where it is applied. (See 18.4.3 Consolidation of Media.)

D. Synthetic Polymers

1. Poly Vinyl Acetate Solutions
    a. General Information: Poly vinyl acetate is a thermoplastic, odorless, non-toxic, essentially clear and colorless resin that has been used in conservation since 1930. The PVA resins made by the American-based Union Carbide Corporation are known as the AYA series: AYAA, AYAB, AYAC, AYAF, AYAT. The physical properties of these different resins (including solubility, viscosity, softening point, heat-seal temperature, tensile strength and glass transition temperature) vary primarily because of differences in molecular weight. (See AIC/BPG/PCC 46 Adhesives pp.47-51.)
    b. Preparation: Solutions of PVA resin, which is usually sold in bead form, are prepared by suspending the beads in a cheesecloth bag inside a jar of solvent. Depending on the solvent, it may take 12 or more hours to dissolve the beads with occasional stirring. At room temperature PVA resins are soluble in acetone, alcohols, toluene, chlorinated hydrocarbons and several other solvents. (See AIC/BPG/PCC 46. Adhesives p.49.) A small amount of water often aids in the solubility of the resin in many solvents.
    c. Use: Among the various PVA resins that are available, PVA AYAC has been principally used in paper conservation as a consolidant. To date, however, it has not been employed for this purpose in parchment conservation. Several PVA resins have been recently used as an adhesive in the repair of objects made from parchment and other untanned or semi-tanned skin materials. A mixture of 25g PVA AYAF and 25g PVA AYAT in 180 ml acetone and 20 ml cellosolve acetate was used for the repair of two 18th c. parchment Battledores at the Winterthur Museum. Although the adhesive worked well the tackiness and working time were diminished because of the volatility of the acetone (Ozone 1985). In two other cases, PVA AYAA was used on its own or in mixtures with ethyl hydroxyethyl cellulose, for the repair of ethnographic objects. (See Vuori 1985, p.6 and Kaminitz and Levinson 1988, p.4.)
    d. Caveats: PVA resins are considered to possess reasonable flexibility without the addition of plasticizers. However, since they are permeable to water vapor, they are not recommended in situations where protection from moisture is a priority.
2. Polyvinyl Acetate Dispersions
    a. General Information: Poly vinyl acetate dispersions, which are often incorrectly referred to as emulsions, are made by suspending minute particles of PVA resin in water. PVA dispersions can either be

homopolymers or copolymers. Homopolymers require the addition of an external plasticizer, which make them susceptible to embrittlement, discoloration, insolubility and staining. Copolymers do not have these same problems since the comonomer acts as an internal plasticizer, and thus has a stabilizing effect on the adhesive. Many commercial grades of PVA dispersions are available, made by 40-50 different manufacturers. Products currently used in conservation include Jade 403 (Jade Adhesives), Elvace (Reinhold Chemicals), Conservation Materials CM-Bond series, Adhesin A22 (Henkel, Dusseldorf, Germany) and numerous other brands.

PVA is a film building adhesive and tends to sit on the surface to which it is applied. It is thus more likely to be reversed with water or polar solvents than other adhesives that penetrate more into the support.(JFM)

b. Preparation: PVA dispersions are sold as a white viscous liquid. They can be used as is or diluted with water to the desired viscosity. For certain applications one can mix PVA dispersions with other adhesives such as starch paste or methyl cellulose, in order to change the working properties of the material. Although PVA dispersions may sometimes be diluted with organic solvents for the consolidation of unstable media on paper supports this has not yet been done on parchment. (See AIC/BPG/PCC 23. Consolidation/Fixing/Facing pp.12-13.)

c. Use: Described by Giuffrida (1983) for adhering parchment patches over losses in manuscripts. It is currently used in Italy and Germany for parchment repair.

The PVAc, (Adhesin A22, made by Henlke, Dusseldorf) has been tested for use in conservation by Dr. Halmut Bansa in a comparison with other German products. This research has been corroborated by Dr. Robert Fuchs, head of the conservation school in Koln. Currently, this specific adhesive is used in the lab of Dag-Ernst Petersen (Herzog August Bibliothek Wolfenbuttel). The same adhesive has also been used for book restoration at the Bavarian States Library, Munich since the end of World War II. In correspondence, Mr. Petersen writes that "under certain circum-stances, when it is necessary to build a long lasting, flexible and reversible connection Adhesin A22 is used. In order to avoid the splitting off of acid a mixture of two-thirds A22 and one-third CMC is made."

A dilute solution of JADE 403 was recently used to prepare and attach laminates of Japanese paper and goldbeater's skin to the damaged parchment leaves of an Armenian manuscript. (Mowery 1991, pp. 135-136.) Book conservators sometimes use PVA dispersions for certain specific applications, such as in the repair of vellum bindings, where the adhesive's strength and flexibility are desirable features. Combinations of PVA and Klucel-G in ethanol can be used to make Japanese paper repairs more transparent. (See 18.4.11.E Mending and Filling.)

d. Caveats: PVA dispersions will gradually release acetic acid over time and therefore their recommended shelf life is limited to 9-12 months. Dispersions are susceptible to damage by temperatures less than 4.44°C (40°F). They can also support mold growth. Additives may dramatically

affect the aging characteristics of many PVA dispersions and these may be subject to change by the manufacturers at any time. The reversibility of PVA dispersions is often problematic, largely due to their increased insolubility with age. (See AIC/BPG/PCC 46 Adhesives pp.51-61 for further information on aging characteristics, etc.) Tests carried out on Mowolith DM5, a PVA dispersion made by Hoechst in Germany, proved it to be unsuitable for use in the repair of parchment. (See Wouters, et.al 1992.) The undesirable attraction of dust and the blocking of adjacent leaves has been observed on parchment manuscripts that were repaired in the past with an externally plasticized PVA emulsion. (See Cains 1982/83, p.18.)

PVA dispersions vary greatly, and some have better ageing properties than others. In a recent study of poly(vinyl)acetate and acrylic adhesives undertaken at the Canadian Conservation Institute, which used natural instead of artificial aging, JADE 403 performed very well. However, reversibility studies were not performed as part of this project. (See Down, et.al. 1992.)

3. Acrylic Resin Solutions

   a. General Information: Acrylic resins were developed for industrial use in 1931. The n-butyl and isobutyl methacrylates are the acrylic polymers in longest use in conservation, with some of the earliest testing having been done at the Fogg Art Museum in the 1930's. Acrylic resins are addition polymers of acrylic and methacrylic acid and their esters. Rohm and Haas, Philadelphia, manufactures a variety of acrylic resins under the trade name Acryloid (called Paraloid in Europe). Although many other acrylic resins are manufactured by different companies, the Acryloid series has found the widest use in the conservation of parchment and other untanned or semi-tanned materials. Acrylic resin solutions are strong, durable adhesives with excellent flexibility characteristics.

   b. Preparation: Acryloid B-72, a 70% ethyl methacrylate, 30% methyl acrylate copolymer, is available as colorless beads of resin or as a 50% solids solution in toluene. B-72 is unique among acrylic resins in having a high tolerance for ethanol and it is frequently dissolved in this solvent when used in parchment conservation. It is also soluble in several other organic solvents, including toluene, xylene, acetone, MEK, ethyl acetate and amyl acetate. B-72 is insoluble in isopropanol. Acryloid B-48, a methyl methacrylate copolymer, has also been used on occasion for the conservation of non-tanned skin materials. Solutions of acrylic resins are prepared by suspending the beads in a cheesecloth bag inside a container of solvent for 24 hours or more. Sometimes a magnetic stirrer can be useful for speeding up the dissolution of the resin in the solvent.

   c. Use: Acryloid B-72 is currently used in Italy for the consolidation of flaking and friable media on parchment. B-72 is used in Madrid to stabilize media on parchment manuscripts and documents prior to immersion in a bath of polyethylene glycol. (See Vinas 1987.) A tissue coated with an 18% solution of B-72 in toluene was used in 1985 at the Turin Archives, Italy, for the lamination of a perforated parchment

document. In this case the adhesive was activated with heat. A mixture of Acryloid B-72 and EHEC (an ethyl hydroxyethyl cellulose manufactured by Hercules) has recently been used for the repair of ethnographic skin objects (see Vuori 1985, and Dignard 1992) and might also be applicable to parchment repair. (JS) A solution of Acryloid B-48N in toluene has been applied to small pieces of goldbeater's skin, which were then used to repair tears in bird skin. In this case the adhesive was activated with toluene (see Kaminitz and Levinson 1988).

d. Caveats: According to Feller (1971), Acryloid B-72 is the most reversible of the acrylic adhesives; it remains soluble and does not cross-link significantly upon aging. Other acrylic resins, such as Acryloid B-48, tend to cross-link through heat and ultra-violet and visible light exposure. They generally remain colorless and transparent over time. In recent tests, solutions of Acryloid B-72 in ethanol and in diacetone alcohol were rejected as adhesives for parchment repair because of their poor water vapor permeability and because of the surface damage that was caused in attempting to reverse parchment to parchment joins that had been executed using B-72. (see Wouters, et.al 1992).

4. Acrylic Resin Dispersions

a. General Information: Acrylic resin dispersions were formulated in 1953 for use as painting media by artists and for industry. Acrylic dispersions are prepared by emulsion polymerization. Those currently used in conservation are copolymers of acrylic resins: blends of ethyl acrylate and methyl methacrylate made from monomers of methyl, butyl, and other longer chain esters of acrylic or methacrylic acids. Although many different acrylic resin dispersions are currently available, the Rhoplex series made by Rohm and Haas, Philadelphia, are the only ones that have been used to date for the treatment of parchment. The Plextol series, made by Rohm Gmbh in Germany, are widely used in Europe but are not considered to be a direct substitute for the Rhoplex resins. (See AIC/BPG/PCC 46 Adhesives p.72.)

b. Preparation: Acrylic resin dispersions are sold as a milky white liquid of resin solids dispersed in water. They can be used as is or diluted with water or organic solvents. In the manufacture of Library of Congress heat-set tissue Rhoplex AC-234 and AC-73 are mixed together and painted out on glass. Lens tissue is dropped in place on the wet adhesive and allowed to air dry. (The method used at Trinity College Library, Dublin is the same except the adhesive formula is one part Plextol M630 and two parts Plextol B500, diluted in six parts of water. (See Cains 1992 p.154.) Once peeled off the glass the coated tissue is ready for use, either as a heat-activated or solvent-activated repair material.

c. Use: Rhoplex AC-234 has been successfully used, in dilutions with water and/or organic solvent, for media consolidation on both paper and ivory supports. (See AIC/BPG/PCC 23 Consolidation/Fixing/Facing p.13.) However, this particular adhesive has not been used for this purpose in the conservation of parchment artifacts. Heat-set tissue, made according to either the Library of Congress formula or the Trinity College Library

formula (see above), has been used both directly and indirectly in the repair of parchment artifacts. More recently, transparent membrane has been coated with the two acrylic resin dispersions, Plextol M630 and Plextol B500, for use in parchment repair. (See 18.3.3.F Adhesive Coated Membrane.)

d. Caveats: The aging properties of acrylic resin dispersions can vary widely according to how they are manufactured (especially in terms of the additives they might contain) and also how they have been applied to an artifact. In theory, all acrylics are stable to light, resistant to heat and oxidation, and have little tendency to yellow over time. (See AIC/BPG/PCC 46 Adhesives p.75.) Recent research at the Canadian Conservation Institute, which used natural instead of artificial aging for testing a wide variety of polyvinyl acetate and acrylic adhesives, found that the acrylic resin dispersions performed very well. However, among the acylic resins that were tested Rhoplex AC-73 was found to become very brittle and, along with Rhoplex AC-234, its pH fell within the acidic range (i.e. below pH 5) after aging (Down, et al. 1992).

5. Polyamides

a. General Information: Soluble nylon is a chemically modified form of nylon produced by treatment with formaldehyde. From about 1950-1970 soluble nylon was widely used in conservation, for the treatment of stone, ethnographic objects, paper and parchment. The brand used in conservation, Calaton CA or CB, was sold by Imperial Chemical Industries. The English product had the trade name Maranyl. Although soluble nylon is still occasionally described in some publications it is no longer recommended for use in conservation, due to its poor aging properties (see below).

b. Preparation: Soluble nylon is available as a white powder and is generally dissolved in alcohol or alcohol cosolvent systems that include water, aromatic hydrocarbons or chlorinated hydrocarbons. Heat is usually needed for the complete dissolution of the material and the recommended working temperature is 40°C with normal working concentrations of 2-5%. (See Plenderlith and Werner 1971 p.375.) Although soluble nylon could be used in spray form it was generally applied with a brush.

c. Use: Beginning in the 1960's soluble nylon was recommended for use in conservation by A.D. Baynes-Cope and Anthony Werner of the British Museum Research Laboratories and, upon their advice, it was included in the British Standard for Archival Repair.(NP) Soluble nylon was recommended for the reinforcement of very limp, degraded parchments (see Werner 1974, p. 17 and Johnson 1980, p.25) and for the consolidation of flaking or friable paint on parchment supports. Sometimes the soluble nylon was dissolved in warm methanol for media consolidation. Roger Powell used a 3% solution of soluble nylon in industrial methylated spirit for consolidation of media and degraded areas of skin during the treatment of an early illuminated manuscript on parchment. (See Powell 1965, p.264 and Powell, 1974, p.181). A warmed solution of 5% soluble

nylon in ethanol was used at the Walters Art Gallery for paint consolidation in illuminated manuscripts, ca. 1960-77 (Drayman 1968-69). Up until the 1960s soluble nylon was frequently used at the Public Record Office, London for the reinforcement/consolidation of parchment documents.

d. Caveats: When heated in water parchment can begin to shrink at temperatures as low as 40°C (Reed 1975, p.94), which is the recommended working temperature of soluble nylon. Soluble nylon oxidizes upon exposure to light and high temperature and over time it cross-links and become insoluble. In addition, films of soluble nylon become brittle and eventually rupture or pulverize, thus causing damage to the media or support to which it is applied. For these reasons, soluble nylon is no longer recommended for use in conservation.

6. Proprietary Formulations

The following formulations have been used primarily in Russia for the consolidation of friable media and degraded parchment. Although testing may have been carried out by the scientists who originally introduced these materials for used in parchment conservation information on their ageing properties and long term stability is not readily available in the U.S.

a. VA 2 EHA: A co-polymer of vinylacetate with 2-ethylhexyl acrylate (VA 2 EHA) has been used in Russia for paint consolidation in illuminated manuscripts. (See Bykova, et al. 1976 and Mokretsova, et al. 1978.)

b. CEV: A partially hydrolysed co-polymer of vinylacetate with ethylene (CEV) has been recently used in a 2:1 alchol/water solution for the consolidation of flaking paint in Greek illuminated manuscripts (Bykova 1993). According to the author this material, whose properties were investigated by two Russian scientists as early as 1979, is very stable and easily reversed in alcohol.

c. Ftorlon F-24L: A soluble fluoroplast currently used in Russia for the consolidation of flaking/friable media and for the consolidation of degraded parchment. Fluoroplasts are products of the polymerization and copolymerization of fluorolefins and they are considered to be quite inert with respect to their action in air, moisture and oxygen. (See Bykova et al. 1976, Mokretsova, et al. 1978 and Bykova 1993.)

18.3.2 Lubricants

Lubricants are plasticizers which have been introduced by conservators into parchment to enhance the immediate and long-term flexibility of parchment artifacts and to permit reduction of distortions. According to Sully (1992, p.50) the lubricant should ideally "cause a minimal change in surface appearance and should conform to the principles of reversibility and minimum intervention." However, since the majority of lubricants listed below have been found to alter the structure and appearance of parchment, on both an immediate and long-term basis, they are not currently recommended for use in conservation. (For more information see 18.4.8 Lubricants.)

A. Parchment Size with Wine Vinegar or Acetic Acid and Alcohol

1. General Information: Parchment size is an extract of the cohesive materials from new parchment. It is a viscous colloidal solution which is often preferred for lubrication because it is chemically compatible with parchment (see 18.3.1. A Collagen-based Adhesives.) Adding acetic acid helps to solubilize the collagen and produces a more fluid size, allowing it to be spray-applied or applied at room temperature. Alcohol, added as a thinner, improves the penetration of the parchment size; it also has a bactericidal effect. Ethanol is widely used but Reed (1972, p.223) recommends isopropanol which "goes in more slowly, penetrates more deeply, takes longer to evaporate and allows more of the size to be absorbed by the parchment before it sets".

2. Preparation: Wächter's recipe: prepare parchment size (see 18.3.1.A Collagen-based Adhesives.) Combine 1/3 parchment size, 1/3 wine vinegar (5% acetic acid) and 1/3 ethyl alcohol. Modification of Wächter's recipe to reduce acetic acid content: 10% glacial acetic acid in distilled water. Add 1 drop to each 5 ml parchment size.

   Acetic acid must be added before the alcohol, otherwise hydration relationships within the colloidal system are affected with the production of turbidity and granular precipitates (Reed 1972, p.224).

3. Use: Brush application or spraying. Better penetration of the size results if parchment is humid at time of application. (Giuffrida 1983, p.38.)

4. Caveats: The use of acetic acid is controversial; it will soften parchment and should be used in very low concentrations. It can intensify colors (Wächter 1962, p.24) and affect pH-sensitive colors.

B. Polyethylene Glycol

1. General Information: Polyethylene glycols are humectants - hygroscopic materials which exhibit moisture regulating properties in parchment. They supply lubricating moisture to a dessicated skin, thus facilitating fiber movement. Carbowax (Union Carbide) is a polyethylene glycol wax which ranges from soft to hard and from liquid to solid with increasing molecular weight (e.g. PEG 200 to 600 are liquids of increasing viscosity). As the molecular weight and viscosity increase, PEG becomes decreasingly hygroscopic.

   According to the literature polyethylene glycols have the following properties: lubricating, non-volatile, water-soluble, neutral pH, non-corrosive, non-flammable, relatively non-toxic.

2. Preparation: PEGs require little preparation and can be used directly from the container.

3. Use: Hygroscopic stabilization treatment is achieved by maximum penetration of the PEG into the parchment. The best procedure is to use PEGs of low molecular weight (200 - 400) applied by immersion which should continue until the parchment becomes transparent; this indicates its saturation. Can also substitute continuous applications with brush or sponge, keeping the parchment between 2 sheets of polyethylene so that it can be observed. The

parchment is tensioned and flattened. Final drying/ flattening between blotters and under pressure. (Vinas 1987.)

4. Caveats: Slow acting (days, weeks reported in the literature). Thick parchments may need prior humidification to facilitate penetration of the PEG and reduce treatment time. Transparentizes parchment when applied; opacity is regained after several hours of air drying. Can affect media by changing their refractive indices and making them appear more saturated.

C. Urea

1. General Information: Urea is a polar substance which interacts with the polar groups of collagen and weakens the interaction between the polypeptide chains. It separates the latter reducing hardness and deformation (Belaya 1969/70, p.27). Spermaceti wax, sometimes added to urea when used for softening parchment, is an animal wax obtained from the head bones of the cachalot (sperm) whale (extraction process described by Reed 1972, p.238). It has a low softening temperature (40-44°C) and is easily emulsified with water.

2. Preparation: Belaya's preparations (1969, p.50):

   10% alcohol solution of urea:

   - prepare a 50% solution of alcohol: dilute 106 ml of 96% alcohol with distilled water to 200ml.
   - prepare 10% alcohol solution of urea: dissolve 10g urea in 100ml of 50% alcohol.
   - prepare a 20% spermaceti solution: dissolve 20g spermaceti in 100ml pure benzene (!) in a phial with a ground glass stopper.
   - prepare a 2% spermaceti wax emulsion: pour 10ml of this 20% spermaceti "into benzene" (quantity unclear ?) in a phial with a ground glass stopper: add 90ml of 96% alcohol while stirring constantly. Cork; shake vigorously until emulsifies. Stir before use.

3. Use: Use of urea in aqueous or water-alcohol solution, with and without spermaceti wax, was first described by I.K.Belaya (1969). It was formerly used extensively in Russia and by some Western restorers. Possibly still used at the British Library for the general softening of parchment (Quandt 1993).

   Very deformed and brittle parchment is cleansed with water followed by rapid drying with 96% ethanol; then it is immersed in the urea solution. Next it is pressed. 2% spermaceti wax emulsion is rubbed in to increase the strength and elasticity of the parchment. (Detailed instructions given by Belaya 1969, pp.49-51.)

4. Caveats: Urea solutions may partially hydrolyse the collagen and also affect the parchment similarly to water-based systems (Yusupova 1980, p.59). Its use in Russia has now been discontinued because manuscripts previously treated with urea have become more transparent (Yusupova 1980, p.59) or to have darkened (Quandt 1993). Urea is now used in Russia exclusively for the separation of sheets stuck into blocks. (Yusupova 1980, p.61.)

The use of spermaceti wax is often accompanied by formation of an uneven white coating (excess spermaceti) which can be easily removed with benzene. (Yusupova 1980, p.60.) It may become rancid through oxidation. Toxicity of benzene contraindicates its use.

D. Leather Dressings

1. General Information: Proprietary leather dressings (containing lanolin, neatsfoot oil, etc.) have sometimes been used to soften and lubricate parchment. Neatsfoot oil is a yellowish, nearly odorless oil extracted from the feet of cattle and sometimes sheep. The solid components crystallize out at low temperatures and are filtered off in the production of cold tested neatsfoot oil (Landsmann 1993, p.30). Lanolin or unbleached wool wax (softening range - 58-62°C), is an animal wax that occurs in many forms. It has excellent emulsifying action and does not easily go rancid. Good penetrating power makes its application easy. Beeswax, also an animal wax, (softening range 62-66°C), is slightly harder than lanolin and is used to give body to the dressing. (Reed 1972, pp. 238-239.) Cedarwood oil, a pale yellow oil, is obtained by treating cedarwood with hot water and steam. It is sometimes used as a thinner, as well as a vehicle to control the consistency and composition of leather dressings; however, cedarwood oil is used mainly for its fungicidal action. (Reed 1972, pp.240-241.)
2. Preparation: British Museum Leather Dressing (200g anhydrous lanolin, 15g beeswax, 30 ml cedarwood oil mixed into 350 ml hexane - e.g: proportions differ from recipe to recipe - to form a paste). For preparation details see Reed 1972, p.242. 'Pliantine' is a later variation of BMLD in which the hexane was replaced by trichlorethane (Genkleen). Talas leather dressing: the beeswax has been replaced by neatsfoot oil. (Landsmann 1991, p.33.)
3. Use: According to Reed (1972, p.242) the parchment is first conditioned to a relative humidity of 60-70%. Rub paste evenly over surface with finger. Leave for a day or two at room temperature; then decide whether further treatment is necessary. With parchment one application is usually enough.
4. Caveats: Neatsfoot oil and British Museum Leather Dressing left the surface of the parchment tacky. (Gowers 1975, p.4-5.) Considerable damage may be incurred by this treatment. (see Reed 1972, pp.242-243.) Lubricants should not be applied to non-tanned skins as they will unacceptably alter appearance - increased transparency. Glossy finish imparted by beeswax component may be unacceptable on parchment. (Reed 1972, p.242.)

E. Glycerin (also known as Glycerol)

1. General Information: Formerly recommended for the lubrication of horny parchment.

"Glycerol is neutral in reaction and acts as an antiseptic, even when largely diluted; . . . It is soluble in a mixture of 2 volumes of absolute alcohol and 1 volume of ether [ether not identified; could be ethyl or petroleum ether] a

fact which may be employed to separate it from the sugars, gums, gelatin, and various salts. Glycerol also dissolves . . . the vegetable acids and all deliquescent salts. It is highly hygroscopic, absorbing as much as half its weight in water when exposed to damp air." (Allen p. 451.)

2. Preparation: Used as an aqueous solution with a small addition of spermaceti wax (Mizin's spermaceti emulsion) in an organic solvent: 96% alcohol: 95ml; glycerin: 2ml; 4% spermaceti wax in benzene: 3ml (Belaya 1969, p.23). Glycerin is also a constituent of egg softener and lanolin emulsions, see 1.3.2.G Lubricants.
3. Use: Glycerin emulsions usually applied directly to the surface of a parchment artifact.
4. Caveats: Glycerin softens parchment greatly but also reduces its strength. It increases the hygroscopicity of parchment by 150-200%, making it sticky and leaving it vulnerable to mold and other micro-organisms. Concentration of spermaceti in Mizin's recipe is so low that practically no softening is obtained. (Belaya 1969, pp.25,27.) Glycerol renders the parchment transparent; also the softening effect is not permanent. (Wächter 1962, p.24)

F. Alcohol

1. General Information: Non-hygroscopic polar solvents (isopropanol, ethanol, methanol) function as softening agents by hydrogen bonding with hydroxyl groups in the fiber structure without causing hydration. They have been used to reshape water sensitive materials such as degraded, distorted vellum (Sully p.50).
2. Preparation: Alcohol solutions require no special preparation when applied to parchment, other than mixing to the desired proportions.
3. Use: Current practice is to immerse parchments in 70% ethanol-30% water bath though water may vary between 20% - 50% and ethanol between 50% - 70%. (Lefevre & Chahine 1986, p.165.) Pure methanol has also been found extremely useful in the softening of parchment yet this practice has been largely discontinued because of the extreme toxicity of the solvent. The conservation literature also notes the use of softeners such as lanolin, egg-yolk, spermaceti, glycerin, etc., to alcohol baths. (Lefevre and Chahine 1986, p.166.)
4. Caveats: Methanol is highly volatile and toxic. It is unpleasant to use and has no advantage over ethanol/water solutions (Cains 1982/82). Immersion in these solvents must be followed by tensioning/pressing or the parchment will dry distorted. Too strong a pressure may result in transparency of the parchment. The presence of water in alcohol/water solutions may cause alteration of surface preparations and coatings and may have a damaging affect on the media. Alcohols may also cause some dehydration of the skin.

G. Other Lubricants

1. General Information: Emulsion treatment has been undertaken to compensate for the fatty substances postulated to have been lost by the parchment

through natural ageing and poor environmental conditions. The qualitative and quantitative compositions of emulsions vary greatly.

2. Preparation and Use: According to medieval recipes, to exploit effects of oils and fats fully, their even application was essential. Emulsoid systems (e.g. egg yolk, milk, butter suspensions, etc.) worked thoroughly into the wet pelt, before drying on the stretching frame, softened the handle of the parchment and enhanced its water resistance. (Reed 1972, p.170.) Technique of use of natural emulsifiers is described by Yusupova 1980 p.58.

   Egg yolk softener/ egg emulsions: egg yolks contain phospholipids, highly polar fats which bind readily with water. Combine into a thick paste egg yolk: 30-40g, glycerine: 20-30ml, distilled water: 20-30ml, ammonia: 3ml, spirit of soap: 10ml, thymol: 2% of the whole mixture. Use as directed above for lanolin emulsion (Belaya 1969, p.24; for Reed's recipe 1972, p.245).

   Spermaceti wax (described 18.3.2.C Urea). Spermaceti-glycerin emulsion: for its preparation (see 18.3.2.E Glycerin) Spermaceti-lanolin emulsion.

   Lanolin or wool wax (described 18.3.2.D Leather Dressing). Lanolin emulsion: 96% alcohol: 50g, distilled water: 100g, lanolin: 5g, glycerine 10g, neutral soap: 2g. Parchment is humidified, egg-softener (see below) or lanolin emulsion is applied, the parchment is "straightened out on glass" and partially dried; then it is pressed between sheets of filter paper and cloth (Belaya 1969, p.24). See also Reed 1972, p.238 for its preparation.

3. Caveats: The use of the above lubricant mixtures is now outdated for a variety of reasons. They have not proven to achieve the necessary softening effect on dessicated parchment. It has proved difficult to determine dosage and so application has resulted in stickiness and transparency of parchments.

   With egg softener and lanolin emulsions the text may be damaged by their application and the parchment may become transparent. The former is also attractive to micro-organisms (Belaya 1969, p.25).

18.3.3 Mending, Filling and Lining Materials

A. Parchment

1. Types of Skin

   a. Full thickness skins: Of the three most common types of parchment that are presently used for repair work - calf, goat and sheep - the first two are only available as full thickness skins with an intact grain layer. (Although the process of splitting seems to have been done on a variety of animal skins during ancient times, and perhaps also during the medieval period, knowledge of the technique was gradually lost over time and is no longer practised.) Modern calf and goat parchment may, however, be reduced to a variety of thicknesses by scraping and/or sanding from the flesh side. It is also possible to have the grain side thinned down to some degree, if the hair follicle pattern is too pronounced or if a soft nap is desired on that side. Depending on the parchment maker, one can often special order a batch of skins for a particular job that are made from a certain type of animal (usually calf or goat) and that have a specific thickness and surface preparation. This

service is currently available from William Cowley Parchment Works in England, as well as some of the other modern firms that provide the type of skins that are most commonly used in conservation.

b. Split Skins: Although some manufacturers sell full thickness sheepskins (i.e. Gentilli in Rome), most modern parchment made from sheepskin is only available as a split skin. (The grain splits are usually tanned and made into a very thin type of leather called "skiver".) Although it is usually the inner flesh split of sheepskin that is made into parchment, grain splits can also be obtained from some manufacturers including William Cowley Parchment Works in England.

c. Parchment Shavings: Shavings that come off of new skins, as they are scraped down by the parchment maker on the frame, are used by some conservators when very thin pieces of parchment are needed for repair. (Lee 1992, p.48.)

2. Preparation

a. Thinning: If a particular thickness of parchment is needed for repair it can be thinned by the conservator using a technique described by Cains (1982/83, pp.17-18). A small piece of the new parchment is taped to a light box with the flesh side up. With illumination from below, the skin is gradually thinned using a sharpened spoke shave blade. The hair side, which does not respond very well to scraping, can be reduced to some degree by sanding or pouncing. In most instances, however, it is preferable to keep the grain layer intact since it the strongest and most compact part of the skin. Sometimes one can mechanically thin a piece of sheep or goatskin parchment by making a cut at the edge and carefully peeling away a layer from the flesh side, following the fiber direction of the skin. (Margotieva and Bykova 1991) The disadvantage of this method is that it is usually difficult to control the size and thickness of the piece that is removed, because of how the collagen fibers in parchment are oriented. It also produces a weak product which is only really useful for cosmetic work. (AC)

b. Toning: Sheepskin parchment (flesh splits) can be obtained pre-toned from William Cowley Parchment Works in England. These skins are currently used in many large libraries and record offices in the U.K. Many conservators however, both in the U.S. and abroad, prefer to tone their repair parchment using leather dyes. Cains (1982/83, p.22) describes a toning method using powdered aniline dyes that are diluted in water (roughly 0.25g/L) to the color of tea. The new parchment is lightly sanded on the hair side, humidified and then immersed in the cool dye bath. The skin is removed after about 5-10 minutes, drained and then tensioned on a board with clips and pins. After air drying the skin is then dried under pressure, between polyester web and blotters, before it is ready for use. (Depending upon the conditions in the workshop it may take several weeks for the moisture content in a skin dyed in this manner to stabilize. AQ)

Leather dyes that are soluble in organic solvents (ethanol or isopropanol being typical diluents) can be applied by immersing the parchment in a bath or by spraying it on the surface of the skin with an air brush.

The advantage of using solvent-soluble dyes is that the skin dries very quickly, thus enabling the conservator to tone the repair piece just before it is adhered in place. In order to match the dark purple color of a mold damaged manuscript one conservator has recently used watercolors to tone his parchment fills, much in the same way that one might tone inserts in paper conservation (Maggen 1991, p.127). Although a darker, more intense color can be achieved by the use of watercolor or acrylic paints they tend to sit more on the surface of a new piece of parchment than would a leather dye, which is more effectively absorbed by the skin. Therefore fills toned with paints can be more subject to abrasion and smearing, especially if the original artifact receives a lot of handling following its restoration.

3. Use: If the repair parchment is left its natural color, and not toned in an aqueous dye bath prior to use, a pre-conditioning treatment is recommended. In this case the new parchment is carefully humidified and then tensioned with clips and pins in the usual manner. This process removes a certain amount of stress in the skin (introduced during the manufacturing process) and allows the repair parchment to come into equilibrium with the workshop environment and with the artifact being treated. (AC)

   The edges of new parchment are usually beveled in a variety of ways prior to repair, in order to have a better bond with the original artifact. For large inserts the parchment may be used in combination with animal membrane or reconstituted collagen, which acts as a supporting bridge on to edges of the artifact. A variety of adhesives may be used to attach new parchment - the most common being parchment size or gelatin. (See 18.4.11 Mending and Filling.)

4. Caveats: The quality of new parchment purchased for repair can vary greatly according to the type of animal skin from which it was made and the way in which it was processed. Parchment made from split sheepskin is often of a uniform thickness, quite white in color, with a hard and sometimes slightly shiny surface and no obvious grain pattern. Its tensile strength is relatively poor compared to full thickness skins, but this property may be advantageous in certain situations. Skins that have the grain layer intact (i.e. calf and goat) can often have a distinct follicle pattern, depending on the degree of surface preparation. The thickness and flexibility can vary considerably across the skin so that only certain areas are suitable for use in repair. These parchments are usually warmer in color and have a softer nap than split sheepskins and are generally preferred for the repair of early manuscripts that are also made from calf or goatskins.

   It is often difficult to determine the exact methods of some modern parchmentmakers, who may rely more heavily on the use of strong chemicals and bleaching agents in order to speed up the manufacturing process and to achieve certain visual effects with their products. It is therefore important for the conservator to familiarize themselves with the

source of the parchment they are using for repair and, if possible, to provide specifications for the type of product that is desired.

B. Animal Membrane

1. Types of Membrane

   a. Goldbeater's skin is a thin, transparent membrane with great tensile strength which was traditionally used as an interleaf for the manufacture of gold leaf. It is made from the outer membrane or caecum of cow intestine and is composed primarily of elastin. The preparation of goldbeater's skin, described in detail by Thompson (1983) and Giuffrida (1983, p.30), is a very labor-intensive and smelly process. Although some conservators find that they have more control over the quality of the final product if they prepare it themselves (Wouters, et.al. 1992, pp. 68-69), the membrane is also available ready-made from two American suppliers, Bookbinders Warehouse and Bookmakers, as well as from Henk de Groot in Rotterdam and several companies in France.

   b. Fish skin membrane is made from the swim or air bladder of certain species of large fish such as sturgeon, hake, cod or whiting. "These organs are essentially inflatable bladders, made from a tough form of connective tissue containing a fibre network based on a type of collagen which is called ichthyocoll." (Reed 1972, p.131) Fish skin membrane was used by the British book conservator Sandy Cockerell in the early 1960s, for the repair of a parchment manuscript with perforated text. Its use was later described in print by Anthony Cains (1982/83). Fish skin membrane is currently avilable from the American firm of Long and Long, Belleville, N.J.

2. Preparation

   a. Degreasing and pumicing the surface: In order to assure a strong bond with the artifact transparent animal membrane is usually degreased by wiping the skin on both sides with a large cotton pad dipped in acetone, or by immersing the skin in a bath of solvent. Another method of degreasing involves spraying the skin with ethanol and then dusting it on either side with magnesium silicate or Fuller's Earth. The skin is left in a closed container for about two days, after which it is removed and the excess powder is brushed off the surface.(UB) A recent study has shown that while the water-vapor permeability of goldbeater's skin is not significantly altered by degreasing, about 40% of the mean tensile strength of the skin is lost during this treatment. However, the reduction of tensile strength is not considered to be a problem when compared to the obvious benefits of degreasing. (Wouters, et al. 1992, p. 69.) Some conservators also like to abrade the surface of goldbeater's skin or fish skin to a slight degree so that it will "key" better to the object. In this operation powdered pumice or pounce is rubbed into the two sides with a cotton pad and the excess is then removed with a stiff brush. (Cains 1982/83.)

b. Toning with leather dyes: Although not widely practised, it is possible to tone goldbeater's or fish skin using leather dyes in the same manner in which one would tone new parchment for repair work. (see above)

c. Attaching membrane to a temporary backing:The mounting technique developed by Anthony Cains gives the conservator more control in handling transparent membrane, which can be very reactive when aqueous adhesives are employed. Heat-set tissue is lightly tacked onto the surface of the degreased and pumiced membrane using a heated platen press, set at 60°C. (Cains 1982/83). If such a press is not available a tacking iron or domestic iron may work as substitutes. However, because of the smaller surface area of these tools, it can be more difficult to mount a large piece of membrane without getting a lot of distortion in the skin. An organic solvent, such as ethanol or acetone, may also be used to activate the adhesive on the heat-set tissue in order to attach it to the membrane. However, if the tissue is completely wet out with solvent it may stick too well to the membrane and be difficult to remove later on.

   Another temporary mounting technique developed by Ulrike Berger involves the use of polyester web as the temporary support. The polyester web is coated with a dilute solution of Tylose MH 300 in water. The prepared goldbeater's skin is positioned on the adhesive-coated web and then dried in a sandwich of polyester-web and blotters under slight pressure.(UB) Other conservators have used different types of plastic film as a temporary support for transparent membrane, but these are only applied just before the membrane is set in place over the damaged area. (See 18.4.11.C Transparent Membrane Repairs.)

3. Use: Since transparent membrane is so thin there is no need to chamfer or bevel the edges of the skin prior to repair. Membrane is most often used for the transparent repair of small tears and weak areas in a parchment artifact. It is sometimes used in combination with new parchment, when large inserts need extra support across the join to the original artifact (see above). Goldbeater's or fish skin can also be successfully laminated with Japanese paper, using either starch paste, PVA dispersions or gelatin as the adhesive. (See 18.4.11 Mending and Filling.)

4. Caveats: Goldbeater's skin and fish skin are both natural membranes and can therefore be quite variable in size, thickness and degree of transparency. Depending on the type of processing that they receive it is often possible to buy inferior skins that were not sufficiently cleaned and that still contain a lot of fat deposits on the surface. The color can also vary as well, especially with fish skin which sometimes can have a distinctly yellowish tone. It is recommended that the conservator purchase several membranes at one time, of either goldbeater's skin or fish skin, and then separate out into groups those that are more similar to each other in color and thickness. These skins can then be selected for use in situations where they would be most suitably matched to the color and weight of the parchment that is to be repaired. (AQ)

   Even when degreased and pumiced natural membranes tend to have a very smooth and somewhat reflective surface which can be distracting when

applied to parchment with a soft nap.(JFM) Despite their relative thinness and flexibility natural membranes can sometimes be too strong when applied to very degraded parchments. In these cases Japanese paper is often a more suitable repair material.

C. **Reconstituted Collagen (Sausage Casing)**

1. General Information: A variety of different types of sausage casing are made for the food industry yet not all are suitable for use in conservation. The majority of these materials are either fully synthetic polymers or reconstructed protein fibers. Both contain several types of additives including vegetable fibers which increase their tensile strength. The width, thickness, color, transparency and strength of different sausage casing products can vary considerably. In general, they are not as strong or as transparent as natural membranes such as goldbeater's skin or fish skin. Three types of Israeli-made sausage casing, of thicknesses ranging from 0.06 - 0.12 mm, were recently evaluated for use in parchment conservation. The results showed that the collagen content differed greatly between the three samples. In addition, they all contained several impurities which, although not identified in these tests, seemed to influence the observed reduction in pH of the material after boiling. (Maggen 1991 pp.122-123.)
2. Preparation: Since sausage casing comes as a compressed tube it is necessary to slit it open and flatten it out prior to use. Washing the casing under running water removes the glycerin which is applied as a softening agent during manufacture. The casing is briefly immersed in a saturated solution of calcium hydroxide and then rinsed in running water. This alkaline wash is said to soften the skin for more effective use during repair. The strips of sausage casing are finally pasted out flat on a sheet of terylene or plexiglas and allowed to air dry. Once dry the strips are rolled up and stored for later use. (Woods 1986, p.6) Since sausage casing is much thicker than the natural membranes, and is not as reactive to moisture as are goldbeater's skin and fish skin, there is no need to mount it on a temporary backing for the purposes of repair.
3. Use: The use of sausage casing for the repair of parchment documents and other artifacts was first suggested in 1970 by Dr. James Lewis of the Imperial College of Science and Technology in England. Sausage casing made by the Scottish firm, Devro Ltd., was found by Dr. Lewis and others to be the most reliable for use in conservation, compared with similar products. It was found to be more uniform in thickness and structure, and it also has a neutral pH after processing (Woods 1986). The primary advantages of using sausage casing for parchment repair are that it is much less expensive and more readily available than goldbeater's skin or fish skin, and it is also easier to prepare and apply to an original artifact. For these reasons, sausage casing has been adopted for use in most large British libraries and record offices. Whether or not its use is as widespread in other countries is uncertain.(AQ) Although most restorers in Britain tend to use wheat flour paste for all aspects of parchment repair, one conservator recommends a mixture of rice starch

paste and parchment size for mending parchment with sausage casing. (Woods 1986, p.6) In either case the adhesive is applied to a piece of prepared sausage casing, which is positioned over the tear or loss and boned in place. Sometimes the casing will be used in combination with new parchment, when a large fill needs additional support across the join to the original artifact. (See 18.4.11 Mending and Filling.)

4. Caveats: Although reconstituted collagen is available in very long lengths its width is limited to the diameter of the sausage products for which it is made. Depending on the country of manufacture, this can vary from about 1 to 3 inches. Sausage casing can be made from a variety of materials including collagen and these additives can adversely affect its ageing properties. (Maggen 1991.) Some products have become brittle and weak in a relatively short period of time.(LP) Sausage casing is not as thin or transparent as goldbeater's or fish skin, nor does it have the same kind of flexibility or tensile strength as the natural membranes. Its dark color also makes it more visually obtrusive. For these reasons the use of sausage casing for parchment repair is not very widespread, with the exception of large archives and libraries in the U.K.

D. Japanese Paper

1. Types of Paper: A variety of handmade and machine made Japanese papers are currently used for the repair of parchment. They can be laminated to match the exact thickness of the original parchment. The strength and weight of Tim Barrett's Minter Tear Guard paper, made from 100% kozo fiber, has made it useful for mending tears in parchment book leaves as well as for closing splits and breaks in parchment bindings.(JFM)

2. Preparation: Japanese paper can be toned prior to use with watercolors or acrylic paints. However, since the color of a pre-toned paper can often appear darker once it is applied, some conservators prefer to tone the mend after it has been adhered and dried under pressure. Relatively dry paints, pastel or chalk, lightly applied with a stippling brush, can be used to tone the repair once it is in place.

   In order to make it look more like parchment the surface texture of Japanese paper can be altered in several ways. A thick wheat starch paste can be brushed on the surface of the paper, which is then dried with a tacking iron. For greater surface sheen burnish the paper through polyester web or polyester film using a bone folder. The shininess can be enhanced even further by coating the paper with gelatin and then burnishing. The flexibility of an insert can be adjusted by laminating several thinner papers together and by boarding a stiff paper or laminate.(LP)

3. Use: Handmade Japanese paper is currently used at Columbia University for the repair of vellum bindings and small sheets of parchment.(FB) Japanese paper can be useful for areas where a skin infill may cause too much resistance. The tissue will deform more easily, thus avoiding cockling or release of the mend.(JM) Japanese paper is often employed for multiple spine fold repairs of manuscripts when the use of new parchment would be either too time consuming or expensive.(NP) In these situations the suppleness of Japanese paper is advantageous in that it does not create a

breaking edge along the spine fold. (The suppleness can vary, however, depending on the type of adhesive that is used and the weight of individual papers within a laminate.) (NS)

SC6000, an acrylic polymer and wax emulsion described by Haines (1987), has been recently used by some conservators to make a Japanese paper mend more similar in appearance to a smooth parchment. After the mend is in place, the emulsion is lightly rubbed into the paper and then burnished with a bone folder.(TW) At the Folger Library Japanese paper mends are adhered with a PVA dispersion (JADE 403) and then coated several times with a solution of Klucel-G in ethanol. Burnishing with a Teflon folder helps to make the mend more invisible.(JFM) (See also 18.4.11.E Japanese Paper Repairs.)

E. Western Paper

1. Types of Paper: Handmade western paper has been used in the past for the repair of parchment documents and manuscripts. It was used occasionally by the British book conservator Sandy Cockerell for the repair of edge tears in parchment manuscripts. He generally preferred Whatman Bank which was split in half (using traditional paper splitting techniques) in order to achieve a thinner paper.(AC) Machine-made papers were occasionally used in the 19th and 20th centuries for the repair of manuscripts and parchment documents.
2. Preparation: Handmade or machine made paper can be toned with watercolor or acrylic paints, although it was not commonly done by those who used the material in the past.

F. Adhesive-coated Tissue or Membrane

1. Lens Tissue Coated with Acrylic Resin Dispersions: Heat-set tissue, made according to either the Library of Congress formula or the Trinity College Library formula (see 18.3.1.D Synthetic Polymers), has been applied to transparent membrane as a temporary facing, in order to facilitate its use in the repair of parchment (Cains 1982/83, p.17). The same coated tissue has also been adhered with solvent directly to the artifact, as a means of supporting tears and perforated areas during humidification and flattening operations and for keeping fragments in alignment during conventional repair with gelatin and transparent membrane (Cains 1992).
2. Japanese Tissue Coated with Cellulose Ethers
   a. A lightweight Tenjugo tissue coated with solutions of Klucel-J in ethanol or ethanol/acetone has recently been used at the Walters Art Gallery for the repair of a mold-damaged manuscript. The dry tissue is placed adhesive side down over the damaged area, ethanol or acetone is applied with a brush or a swab through the tissue, and the mend is gently pressed in place.(AQ)
   b. Frank Mowery makes an extremely thin and transparent repair tissue from kozo fiber which is formed on a leaf caster. (The product, called Gossamer Tissue, is commercially available from Bookmakers International.) A thin solution of Klucel-G in water is applied to the tissue by brush or spray, or by using a roller through a piece of screening

material. It is especially useful for overlaying damaged areas of text or illumination in documents and manuscripts on both paper and parchment supports. The adhesive-coated tissue is positioned over the damaged area and the adhesive is activated by moistening with ethanol or acetone.(JFM)

3. Japanese Tissue Coated with Isinglass: A medium weight Japanese tissue, coated on one side with a solution of isinglass, is currently made by Tatyana Petukova, a paper conservator at Cornell University (Petukhova and Bonadies 1993). (Although not readily available at the present time the product may be marketed commercially in the near future.) It has been used at the Pierpont Morgan Library for the repair of parchment. Once the repair tissue is positioned the adhesive is activated with moisture, introduced through Gore-Tex. The application of the mend can thus be very gentle and controlled.(DE)
4. Synthetic resins on transparent animal membrane
   a. Transparent membrane coated with methacrylates: A solution of Acryloid B-48N in toluene has been applied to goldbeater's skin and used for the repair of an ethnographic object made from the bodies of small birds. (Kaminitz and Levinson 1988.)
   b. Transparent membrane coated with acrylic resin dispersions: The two acrylic resin dispersions, Plextol M630 and B500 (prepared in the same manner as for Trinity College Library heat-set tissue - see 18.3.1.D Synthetic Polymers) have been recently applied to transparent membrane (fish skin) and used for the permanent repair of cracked and perforated parchment manuscripts that have been damaged by acidic media. (Cains 1992, p.155.)

G. Pulp Filling/Leaf Casting Materials

1. Purified Hide Powder: This technique was recently developed in Belgium (Royal Institute for Cultural Heritage, Brussels) for the repair of a severely mold-damaged illuminated manuscript on parchment. (Wouters, et.al. 1993.) The method uses a hide powder which is prepared from calf hides that are limed, delimed, dehydrated with acetone and then milled. (This powder, which is made for other commercial uses, is obtained from the Leather Trade House, Northampton, England.) An aqueous suspension of hide powder is prepared in 0.03% Tylose MH300. Mild pretreatment with formaldehyde and additional calcium carbonate may be used to tune the opacity of the final preparation. In order to assure that no residual formaldehyde remains in the final pulp mixture, thorough rinsing is carried out until a negative test with the indicator fuchsin is obtained. (The use of this pulp mixture for repair work is described in 18.4.11.I Pulp Fills.)
2. Hide Powder and Eukanol Glanz N: This pulp filling technique was developed by the Danish paper conservator Per Laursen. (Laursen 1985.) The so-called "parchment" powder is not made from new parchment but from goat or calf skins, which are obtained from a commercial tannery in a raw state, cleaned of their hair and flesh. The wet skins are delimed in a large vat, dehydrated with alcohol and then hung up to dry. The skins are

cut into small pieces and ground into a powder using a grinding machine. The powder is used in this pure state, without the addition of any other materials, for the filling of losses in parchment artifacts. (It can be obtained ready-made from Mr. Per M. Laursen, Baunebjergvej 113, DK-3050 Humlebaek, Denmark.) Since the powder is applied with an atomizer in a dry state an adhesive is then added in a second step, in order to bind the fill together and make it adhere to the original. The particular product chosen by Laursen, Eukanol Glanz N 103 543, is made by Bayer in Germany and consists of a synthetic casein which contains aluminum. (It is normally used in the leather industry as a surface finish for tanned and dyed skins.) For pulp filling the adhesive is diluted with ethanol to make solutions varying from 10% to 50%, depending on the particular situation. It is applied to the pulp fill using either a brush or a spray gun, while the object is on the suction table. The suction draws the adhesive through the layer of powder and binds the fibers together. In the case of very large fills it may be necessary to apply a layer of goldbeater's skin to either side for additional support. (See 18.4.11.I Pulp Fills.)

3. Parchment Powder and Ftorlon: This technique is used in Russia primarily for the repair of mold-damaged manuscripts. New parchment is either shaved down or pulverized in order to make a powder, which is then sieved until the desired particle size is achieved. The parchment powder is mixed with a 5% solution of Ftorlon 26 in 1:1:1 ethylacetate/butyl-acetate/acetone and then used to fill losses in parchment artifacts. (See 18.3.1 Adhesives and Consolidants and 18.4.11.I Pulp Fills.)
4. Hide Powder and Paper Pulp: This technique of pulp filling was developed at the National Library in Budapest, Hungary and used for the repair of a large collection of mold-damaged manuscripts dating from the 15th century. (Beothy-Kozocsa, et.al, 1987 and 1990.) The pulp contains a wide variety of materials including parchment powder, five different types of paper fiber, two adhesives, water, ethanol, isopropanol and a fungicide. The so-called "parchment powder" is obtained from a type of limed, yet untanned hide called "Picker" which is used in the textile industry. The hide is cut into strips, pulverized on a grinding wheel and then seived. Before adding it to the pulp the "parchment powder" is swollen in water for 24 hours. Sulfide or sulfated pine cellulose, obtained in an aqueous suspension from a commercial papermaking company, is ground and dried, and then mixed in an alcohol solution with the addition of a fungicide. The ground fibers of four different types of Japanese paper are then added to the pine cellulose to make a final pulp mixture containing 30 g of dry fiber in 2000 ml distilled water. Parchment glue is prepared according to Wächter's recipe (see 18.3.1.A Parchment Size) which includes wine vinegar and alcohol as additives. The second adhesive consists of a 7% solution of hydroxyethylmethyl cellulose. Once prepared all of these materials are blended together and the mixture is allowed to sit for several days until it is no longer foamy. Regular agitation of the pulp avoids settling of its contents. Although coloring agents such as pigments or dyes may be added to the pulp at this point, the conservators in Budapest usually prefer to alter

the color of the pulp by the selection of Japanese papers that go into the mixture.(AQ) (This method is further described in 18.4.11.I Pulp Fills.)

5. Parchment Powder and Glacial Acetic Acid: A European technique whereby acetic acid is added to a small loss filled with parchment powder. The acid gelatinizes the powder and makes it adhere to the original. The disadvantage of the technique is that acetic acid can cause the parchment around the perimeter of the loss to soften.(PY)

H. Lining and Lamination Materials: The following materials and methods are no longer recommended for use in conservation for the following reasons. They have been found to severely limit the ability of parchment to respond to changes in the surrounding environment, thus leading to damage in the original artifact. The reversibility of the laminating materials and adhesives is also highly questionable.

1. Polished Cotton or Linen: Cotton or linen fabric was frequently used in the past in many libraries and archives for lining paper as well as parchment documents, maps and other archival materials. Flour or starch paste was typically used to attach the lining to the artifact. In the U.K. cotton or linen fabric was primarily used during the two world wars for the lining of parchment documents. (Prior to that time new parchment was more typically used as a lining material for parchment documents.)(FB)
2. Silk Crepeline: A very fine weave silk fabric, often called crepeline, was sometimes used in the past for the lamination of parchment manuscripts and documents. Flour or starch paste was commonly used to attach the silk to the artifact. Up until the introduction of heat-activated laminating films in the early 1960's, silking was widely practiced in large libraries and archives and in commercial binderies, both in the U.S. and abroad. Many manuscripts were repaired with silk in the 1950's by a commercial binder in Cambridge, England.(NP)
3. "Mipofolie": Mipofolie is a plastic laminating film that was made in the 1950's by the German firm Alfred Schwarz Gmbh & Co. Analysis of the material has identified it as a vinylchloride polymer, externally plasticized with 30% (w/w) bis(2-ethylhexyl) phtalate (otherwise known as dioctylphtalate). (See Wouters, et.al. 1990.) Mipofolie was used for the lamination of deteriorated parchment manuscripts and documents in Europe during the 1950's and perhaps earlier. Although it was commonly applied with heat, some authors have suggested that an adhesive such as poly(vinyl)acetate was occasionally used to attach the plastic film at room temperature and using only moderate pressure. (See Wouters, et.al. 1990, p.497 and Wächter 1987.)
4. Dry Mount Tissue: Dry mount tissue, and other types of heat-set tissue, are still occasionally used by modern commercial framers for the mounting of parchment documents - often with disastrous consequences. The tissue is usually attached to the artifact with the use of a dry mount press, with the temperature of the press set to the activation temperature of the adhesive.

18.3.4 Mounting and Housing Materials

A. Unbleached Soft Finish Linen Thread (for string mats)

B. Japanese Paper

C. **Western Handmade Paper**

D. **Stabiltex Polyester Netting**

E. **Matboard**

F. **Adhesives - Starch Paste, PVA Dispersions**

G. **J-Lar tape**

H. **Marvel Seal 360 - manufactured by Ludlow Corporation, available from University Products.**

I. **Polyester Film**

J. **Acid-free Corrugated Board (Archivart Multi-Use Board). This expands more than Kraft corrugated for a given %RH.**

K. **Coroplast E-flute board (corrugated polypropylene)**

L. **Fome-core**

M. **Ultra-violet Filtering Plexiglas**

18.3.5 Tools and Equipment

A. General Cleaning and Removal of Old Repairs and Mounts

1. Optivisor, Magnifier or Binocular microscope
2. Kneaded Eraser, Groom Stick and/or Vacuum Aspirator (for mold removal)
3. Vinyl Eraser - Block or Crumbs
4. Crepeline Eraser
5. Electric Eraser with Vinyl Tip
6. Microspatulas, Teflon Spatula, Casselli Knife
7. Scalpels
8. Soft Brush
9. Tweezers
10. Spun-bonded Polyester, Blotters, Gore-Tex Polyester Web Laminates
11. Preservation Pencil (available from University Products)
12. Ultrasonic Humidifier With Hose/Nozzel Attachments

B. Consolidation

1. Fine Sable Brushes (00 or 000)
2. Bamboo Skewer with Bevelled Edge, Teflon Spatula or Spoon Shaped Dental Tool (for setting down lifting flakes of paint and ink) Bone Folder, Teflon Folder
3. Silicon Release Paper or Silicon-coated Mylar (as interleaf for setting down paint flakes)
4. Binocular Microscope with Fiber Optic Light
5. Regular or External Mix Air Brush and Compressor
6. Vacuum Suction Table

7. "Ultrasonic Mister"

C. Humidification

1. Blotters, Polyester Web, Pressing Boards or Thick Plexiglas (with everything cut to same dimensions for damp blotter pack)
2. Gore-Tex Polyester Web Laminates
3. Spun-bonded Polyester (Hollytex, Remay)
4. Blotters
5. Photo Trays, Screens and Plexiglas (for simple humidity chambers)
6. Sodium Chloride (for saturated salt solutions to maintain humidity levels inside chambers)
7. Ultrasonic Humidifier with Hose and Nozzle Attachments
8. Plexiglas Dome or Box
9. Ready-made Humidity Chamber (Weidner, Lascaux, etc. available from Museum Services Corp.)
10. Air Brush and Compressor (for spray humidification)
11. Humidity Indicator Strips or Hygrometers
12. Moisture Meter (Aqua Boy, Sovraign, or Digital Mini Protimeter)

D. Tensioning/Drying

1. Bulldog Clips - jaws padded and made parallel with Ethafoam, thick blotters, or matboard
2. Pins - dissecting pins or home-made pins with wooden dowel and bookbinding needles
3. Insulation Board (Homasote), Ethafoam or Plywood (for pinning out parchment)
4. Lead Sinkers and Heavy Thread (for tensioning weights)
5. Plexi or Glass Strips (for tensioning at edges)
6. Tensioning Frame (See Smith and Bunting 1993.)
7. Vacuum Suction Table
8. Polyethylene, Polyester Film or Rubber Dam Material (for masking off suction table)
9. Thick Wool Felts (preferable to woven papermaker's felts)
10. Spun-bonded Polyester, Blotters (with smooth finish)
11. Gore-Tex Polyester Web Laminates
12. Pressing Boards - thick plexi or glass sheets or formica-covered board
13. Weights (of various sizes and dimensions)
14. Bookbinding Press ("Nipping Press")
15. Moisture Meter (Aqua Boy, Sovraign, or Digital Mini Protimeter)
16. Electric Timer (for monitoring length of humidification treatments)

E. Repair

1. Sanding Sticks - wooden dowel and/or wooden swab sticks covered with sandpaper of various grit sizes
2. Wooden Block with Rounded Edges (to support parchment fill while sanding edges)
3. Small Paring Knives (for bevelling edges of parchment fills)
4. Swivel Knife (for cutting out intricately shaped pieces of transparent membrane)
5. Scalpels
6. Flexible Shaft Drill with Abrasive Bits (Fordom, Dremel)
7. Bone Folders, Teflon Folders
8. Tweezers
9. Brushes
10. Blotters, Polyester Web (small pieces)
11. Plexiglas or Glass Strips and Weights
12. Light Box with Cool Surface
13. Photo Trays or Air Brush and Compressor (for toning parchment and paper)
14. Vacuum Suction Table (for pulp fills)
15. Atomizer, Blender, Eye Dropper, Flexible Plastic Bottle, Polyethylene (for masking around area of loss)
16. Ultrasonic Humidifier With Hose/Nozzel Attachment
17. Diolen (fine silk fabric similar to crepeline)

F. Housing

1. Blotter and Polyester Web (cut in small pieces)
2. Thick Plexiglas or Glass (in small squares or rectangles)
3. Weights
4. Straight Edge
5. Scapel, Mat Knife
6. Board Shears
7. Brushes
8. Tweezers
9. Bone or Teflon Folders
10. Dividers
11. Mat Cutter
12. Ultrasonic Welder or Heat Welder

18.4 Treatment Variations

18.4.1 Cleaning Methods (See AIC/BPG/PCC 14. Surface Cleaning.)

A. Mold (See 18.6.2 Fumigation and AIC/BPG/PCC 12. Mold/Fungi)

Parchment artifacts are frequently the target of mold attack, and these organisms are a health hazard to the conservator. Appropriate safeguards should be adopted when cleaning moldy parchment both to protect the conservator and to avoid contaminating the work environment. Protective equipment such as gloves, apron, and mask or respirator should be worn. The work should be carried out in a fume hood. Aspirators are useful because they pick up mold growth rather than spreading it or more deeply embedding it in the surface. In this technique, the aspirator draws the mold into a pipette attached to a vacuum pump, and passes it through a flask of water where it is collected for safe disposal. (See Lee 1983.) If necessary, the mold is dislodged from the parchment surface using a small brush so that it can enter the pipette.

Any mechanical surface cleaning over media can be dangerous as the binder is often degraded by mold. Therefore, the media can be quite unstable and easily disloged. When mold is brushed from the surface of parchment, a soft brush should be used. In general, brush to the nearest edge of the artifact to reduce the amount of smearing of mold across the surface. To avoid contamination, clearly label the brush so that it will not be used for any other purpose. Erasers are inappropriate when mold is on the surface, as they will grind mold growth further into the parchment. They might sometimes be useful for deeper cleaning after surface growth has been brushed or aspirated away. Mold also grows down into and discolors the interior of parchment, beyond the reach of surface cleaning, and can remain dormant for long periods until a damp environment favors its regeneration.

Some conservators surface clean moldy parchment with cotton dampened with an organic solvent such as ethanol to remove mold growth. This may be more effective than dry cleaning in some cases, and may be preferred because of the reputed fungicidal property of the solvent. Degraded and moldy parchment may benefit from "washing" with alcohol on the suction table prior to consolidation. (Maggen 1991.) The use of solvent, however, will not prevent mold growth in the future.

Mold removal should be carried out before any other treatment step to prevent further contamination. It is especially important that it precede consoli-dation, humidification, or pressing, because all these treatments will make the removal of mold growth more difficult or impossible. Mold-damaged parchment is subject to mold reactivation if it is left in a humidity chamber or damp pack too long.

B. Surface Dirt

If the skin is healthy, (ie. not mold damaged) dry cleaning methods are preferred over aqueous mixtures as the conservator wants to avoid wetting the skin in any way. The aqueous techniques discussed below are only performed in specific circumstances. Just as in cleaning paper, before undertaking any surface cleaning of parchment the conservator should weigh the benefit to the artifact against possible risk to the parchment surface or the media. A dry healthy skin may permit more aggressive surface cleaning than paper would because the surface is more resistant to abrasion. This is especially true when the parchment surface is hard and smooth. In that case, however, it is important to consider whether the surface shininess is due to preparation or a surface coating that may be damaged or altered by cleaning

actions or materials. Also, one should not be tempted to go too far in local areas when a whole sheet cannot be safely or successfully cleaned.

Every type of overall surface-cleaning, even with a soft brush, should be preceded by examination under magnification. Minute flaking of the media is often present and not readily apparent in normal viewing conditions. For dry cleaning, whole or grated white vinyl block erasers are commonly used. However, the surface is especially vulnerable to abrasion if one or both sides of a parchment are open or nappy. In this case the use of powdered erasers is not recommended, because they may become permanently embedded. Electric erasers are used by some conservators, but they can be difficult to control, and a momentary lapse can lead to excessive abrasion.

Certain organic solvents (such as petroleum benzine) can be especially useful for removing greasy soot and ingrained dirt. It may be preferable to use cotton dampened with organic solvent rather than with water for surface cleaning to avoid softening, cockling, and other changes of the parchment. Over dampening with solvent should be avoided to prevent solubilizing components of the parchment (See 18.2.5.G Problems Caused by Use of Organic Solvents.) Sometimes organic solvents are diluted with water (50% water or less) to improve cleaning activity. The use of water based solutions (18.2.5.A Problems Caused by Water or Excessive Moisture) should be guarded against particularly because they can permanently flatten a napped surface or alter a surface coating. Milk is a traditional cleaning fluid that has been used in the past, however, it doesn't appear to be in use today. (See 18.3.2 Lubricants.) Local areas that have been surface cleaned with aqueous solutions should be immediately weighted to avoid excessive cockling.

Use extreme caution when cleaning the margins of medieval manuscript leaves -- these can contain ruling lines drawn in lead point that are often imperceptible to the naked eye. Nineteenth century prints and drawings that are on split skins can be fragile and prone to tearing during surface cleaning if there are small cuts or tears at the edges. Surface cleaning of a degraded parchment may be too risky to undertake (See 18.4.1.A Mold.)

C. Accretions (See 18.4.2 Removal of Previous Restorations and 18.4.5 Solvent Treatments.)

Often careful mechanical removal of accretions with a scalpel under magnification is the simplest and least hazardous method. If this cannot be accomplished without damage to the underlying surface, it may still be desirable to thin an accretion mechanically before attempting to soften the residue for removal. Methyl cellulose is especially suitable for softening water-sensitive accretions because of its tendency to restrain the spread of water and therefore affect the underlying parchment to a lesser degree. Some conservators prefer saliva or thick starch paste for this purpose. Some accretions will soften with organic solvents.

Before removing accretions it is important to make sure that they are not intentional marks. For example, the diacritical marks in a Hebrew or Arabic manuscript can be easily mistaken for flyspecks. It is also important to consider whether the accretions may contain some codicological evidence, especially in the

case of archaeological or religious material, or whether they may be evidence of use in an original context, such as wax drops from burning candles used for reading.

D. Adhesive Residues (See AIC/BPG/PCC 15. Hinge, Tape, and Adhesive Removal.)

Mechanical removal may be the most direct and safe method for some adhesives. A dry, smooth, healthy skin may be able to support the stress of scraping or chipping away a layer of adhesive on its surface when it forms a discrete layer (i.e. it has not penetrated into the parchment). Such thick, crumbly layers are sometimes formed by aged animal glues and starch pastes. Sometimes it may be preferable to soften these adhesives using controlled moisture, such as Gore-Tex and blotters, paste, or methyl cellulose poultices. A swab dampened with saliva has also been successfully used to soften deposits of hide glue. When saliva is used, the conservator should consider whether it is wise to leave residues of enzymes and other materials found in the mouth on the surface of the parchment. If the parchment is to be humidified for flattening, it may work better to plan to remove softened adhesive after overall humidification but before tensioning or weighting. If mechanical removal of the softened adhesive is at all time-consuming, this can be done in stages, rehumidifying the parchment each time it begins to dry out. Mechanical removal of adhesive from a humidified parchment must be done carefully, to avoid marring the softened skin. A Preservation Pencil (from University Products) which delivers a slightly warmed mist has been successful for the initial softening of thick deposits of animal glue. (AQ)

Sticky tape residues may be efficiently picked up with the judicious use of a crepe eraser. Heat is generally not recommended for adhesive removal, because the working temperatures of contact heating tools and hot air blowers that are safe for paper may cause permanent damage to parchment. (See 18.2.5.D Problems Caused by Use of Heat.) However, there are certain instances where the controlled application of heat may be more effective than the use of solvents or other techniques (see 18.4.2.A Local Repairs.) Where the media permit, some adhesives can be reduced or softened using cotton dampened with organic solvent and then removed mechanically. Solvent baths might be considered under extreme circumstances, but the potential for damage to the parchment structure and media must be weighed. (See 18.2.5.G Problems Caused by the Use of Organic Solvents.)

Some adhesive remnants may contain codicological or historical evidence. In other cases adhesive removal may create undue risk or inevitably damage an artifact, such as when an adhesive is found on a nappy or degraded surface. Then mechanical thinning, leaving the last thin residue alone, should be considered. This may be less hazardous to the long-term preservation of a healthy, naturally alkaline parchment than it would be in the case of a paper artifact. Sometimes residues may look disturbing when a somewhat translucent or thin parchment is viewed by transmitted light, but when the sheet is mounted or framed against a suitably light or dark support this unevenness will be disguised. The residues should be thinned/weakened to the point that they will not cause puckering or other deformations over time. Always use added care when attempting adhesive removal on a degraded parchment.

18.4.2 Removal of Previous Restorations

A. Local Repairs (See 18.4.5 Solvent Treatments.)

There are many situations where the removal of previous repairs on a parchment artifact is not advisable. A healthy skin can usually withstand the type of manipulation that would be involved in the removal of an old repair. However, a parchment that has been degraded by mold, or that is weak and perforated from acidic inks or paints, might be further damagaged in the process of repair removal. In these cases one has to weigh the benefits that might be achieved by removing previous repairs, such as revealing obsured text or design or by improving the flexibility of the original parchment, against the possibility of causing further damage. Another consideration is the historic nature of the repair. Once it has been determined that the repair is not original to the object it is important to decide whether or not it is important to retain as part of the history of past treatment. If the repair is actively causing damage, or obscuring a significant portion of the artifact, it probably should be removed. However, appropriate written and/or photographic documentation should be carried out prior to treatment, in order to record the location and appearance of a repair that is considered particularly interesting or historic. The decision to remove old repairs might also be affected by the nature of the artifact and the context in which it will be used and displayed after restoration. For example, there might be more compelling reasons to remove old repairs from fine art prints and drawings on parchment, or a finely painted manuscript leaf, where the aesthetic appearance of the object is of primary concern. Past repair techniques were most likely executed using patches of new parchment or paper adhered with either a collagen based adhesive or paste. If the adhesive is dried out, and if the original parchment is considered strong enough in that area, it may be possible to remove the repair patch and the adhesive residue by mechanical means. Otherwise it may be necessary to locally humidify the repair, by either direct application of an alcohol/water solution (if the repair is relatively small in size) or with a piece of dampened blotter using either polyester web and/or Gore-Tex as an interleaf. Once dampened the adhesive residue can be removed with a microspatula or similar type of tool. Additional methods of adhesive removal, using poultices and saliva-dampened swabs, are described in Section 18.4.1.D.

Although most sewn repairs found on parchment artifacts tend to be contempory with the original, having been executed either by the parchment maker or by someone involved in the fabrication of the object, it is not unusual to occasionally find these types of repairs dating to a much later period in the history of the artifact. In some situations it might be difficult for the conservator to distinguish between an original or contemporary sewn repair from one that has been executed at a much later date. Careful examination of the nature of the damage, the way in which the repair has been executed and the material used for sewing (whether linen, cotton or silk thread, parchment thong or sinew), can be helpful in making these distinctions. If a sewn repair is not causing any obvious damage to the artifact, and if it is stable and not disfiguring in any way, it might be more preferable to leave it in place than to remove it.

A variety of tapes are often found on parchment artifacts, used either as hinges for single manuscript leaves, prints and drawings or as repair materials. Gummed fabric tapes and glassine tapes usually respond well to moisture. These can often be

safely removed using the same methods described for parchment and paper patches above. In both cases, however, it is important to contain the moisture within the area of the repair and avoid creating tide lines with water or water/alcohol solutions. Weak and perforated skins are more susceptible to mechanical damage and removal of repairs from these areas needs to be performed with even greater care, so that the original parchment is not put under any kind of strain. Skins damaged by mold tend to have a more fibrous or pulpy texture and are very susceptible to staining and discoloration from moisture and pressure. In these cases one should use the minimal amount of moisture that is required to remove a repair with a water-soluble adhesive.

When pressure-sensitive tapes are found on parchment artifacts the best procedure is to remove the carrier along with the bulk of the adhesive mass, without driving the adhesive any further into the skin. When the tape is quite old and deteriorated the adhesive mass may have already cross-linked and become very hard and crusty. If, however, the adhesive is still relatively soft it may be possible to use a microspatula, dipped in an appropriate solvent, to slide underneath the tape and release the carrier. Although one must be extremely cautious in using heat near parchment another technique that can sometimes be considered is the use of a heated microspatula for the removal of pressure-sensitive tape. In this case the microspatula is warmed on a hot plate, or on the bottom of a tacking iron, and then used in a slicing action from one end of the tape to the other in order to release it from the object. During this procedure pieces of silicon release paper or siliconized Mylar can be placed under the carrier that has just been lifted, in order to prevent it from reattaching itself to the object. When using this technique one should be careful not to heat the microspatula beyond the temperature that is needed to release the tape carrier. Too much heat will cause the softened adhesive to be driven into the skin and may also cause damage to the parchment support. Residual adhesive can then be removed in a variety of ways, depending upon the condition of the original parchment. The adhesive can be softened in a solvent vapor chamber and then carefully scraped off the surface using a microspatula. Different types of erasers, particularly vinyl or crepe erasers, can be useful in balling up the adhesive residue which is then picked off the surface with tweezers. If the adhesive residue is still somewhat soft and sticky the use of liquid solvent, applied with a brush or with swabs, may only drive the material further into the skin making it even more difficult to remove. Sometimes, however, liquid solvent can be successfully used in combination with poulticing materials such as Fuller's Earth, or with a suction disc. All of these techniques are similar to those that have been developed for paper artifacts and are described in greater detail in the AIC/BPG/PCC 15. Hinge, Tape and Adhesive Removal.

B. Backings and Mounts (See 18.4.5 Solvent Treatments for further details on removal of dry mount and heat-set tissue)

As C. Clarkson states (1980), one of the many unsympathetic ways parchment leaves have been treated has been to "ignore its life and spirit altogether by humidifying it and then sticking it down overall to a card, paper, or wood" or by "drumming it down" (i.e., adhering only the edges of the artifact to a heavy card). These methods unnaturally restrain the skin in such a way that it fights against the mount, often resulting in ruptures or splits in the weaker areas of the skin.

1. Mounts Adhered with Paste or Glue: When separating a parchment support from a paper or cardboard mount, most of the paper and adhesive residue should be removed mechanically and as dry as possible before introducing any moisture. A parchment leaf should never be immersed in a water bath to remove it from a mount, as might be done occasionally with a paper artifact.

   When removing a parchment support from a mount or backing, care should be taken to keep the parchment support flat and in plane, not bending or flexing the support in any way, especially if it has a thick design layer on either recto or verso surfaces. Any actively flaking pigments or inks should be consolidated prior to treatment (See Section 18.4.3 Consolidation of Media.) The leaf is placed face down onto the smooth side of a sheet of Gore-tex or smooth hollytex. Using the edge of a sharpened Casselli knife, metal spatula, or very thin lifting folder, the backing card is slowly delaminated layer by layer down to the final layer of paper that is adhered directly to the verso of the parchment support.

   Only at the final stages of the backing removal should small amounts of moisture be introduced to remove the last paper fibers (using a swab and an ethanol and water mixture) and adhesive residue (using saliva and a swab). These residues are removed in small sections, being constantly mindful not to affect any text ink or design that might be extant on the verso of the support. As complete a removal of any adhesive residue as possible is especially important when dealing with parchment, otherwise these residue layers can create an uneven contracting effect over the surface of the leaf. But if text ink or design does exist on the verso surface, a thin layer of adhesive may have to be left over areas of design should its removal affect the design in any way.

2. Mounts Adhered with Heat or Solvents: Dry mounted parchment that is reasonably strong and healthy, and not weakened by mold, has been successfully treated using mechanical tech-niques. In general, the nature of parchment's surface characteristics do not allow for a strong bond with dry mount adhesive and so in most cases the skin separates rather successfully. Working with the object face up and beginning in one corner, a Teflon spatula can be inserted between the parchment and the mount, causing the skin to lift away from the dry mount adhesive By viewing in raking light the little residual adhesive that remains on the verso can be removed by swabbing with cotton balls dipped in hexane. (JFM)

C. Laminations

1. Silk Crepeline: Silk crepeline was frequently used for the lamination of paper and parchment artifacts, before the introduction of heat-activated laminating films. (See 18.3.3.H Lining and Lamination Materials.) Depending on the relative strength of the skin and the condition of the media, crepeline has been mechanically removed from parchment without too much difficulty, especially when the silk fabric is already partially degraded and if the paste has dried out. In this case, the problem is the removal of the remaining paste which the conservator may opt to leave. Because silking is a wet process that utilizes pressure there are documents

in which the fabric and adhesive are immeshed to both the surface of the media and the support. It is likely that the silk will not release without loss or alteration of the media. If moisture is needed to release the adhesive bond that holds the fabric in place, further damage could be caused to the support as well as to any water-soluble media that might be present.

2. Goldbeater's Skin: Goldbeater's skin was sometimes used in the past for the lamination of weak and degraded parch-ment manuscripts and documents. Since gelatin or parchment size was more commonly used to attach the transparent membrane it usually remains well-adhered to the original artifact. The moisture that would be necessary to swell the adhesive and release the membrane could cause considerable damage to the parchment support and the media. Therefore it is often best not to attempt the removal of a lamination with goldbeater's skin.
3. Mipofolie: A German-made laminating film, Mipofolie, was occasionally used in Europe during the 1950's for the lamination of parchment manuscripts weakened by mold or corrosive inks and paints. (See 18.3.3.H Lining and Lamination Materials.) Two of these laminations were successfully removed from medieval manuscripts in Vienna and in Brussels using a combination of organic solvents and mechanical techniques.

18.4.3 Consolidation of Media (See AIC/BPG/PCC 23. Consolidation/Fixing/Facing, and AIC/BPG/PCC 46. Adhesives.)

The adhesion strength of the design layer to a parchment support is a function of a number of factors: a) the preparation of the parchment surface; b) the painting, drawing, or printing media; and c) the state of preservation and subsequent damage suffered by either the media and/or the parchment support. Only after assessing the condition of the design layer, and establishing that active flaking is occurring and determining its cause, can an appropriate consolidant and method of application be determined.

As S. Keck (1969) states, the deterioration of a paint layer can be the result of any number of chemical, physical, or biological agents, resulting in mechanical damage. In works of art and documents on a parchment support, this mechanical damage usually takes the form of cracking, lifting, or increased friability of the design layer. The most common problem affecting a painted design on parchment is the cracking and flaking that results from the over-handling (flexing and folding) or unrestrained movement of the parchment support (in response to humidity and temperature fluctuations), or from direct abrasion and manipulation of the design layer. Additionally, severe flake loss can occur to a design layer if the parchment support has been inadequately prepared (if the hair-side of the skin is left too slick, for instance) or if the skin has been treated with a surface coating, as in the case of Byzantine manuscripts. (See 18.2.4.B Surface Qualities.)

Furthermore, the binders of some pigments may be affected by environmental factors, condition factors (water damage, biological attack), neighboring pigments, or possibly even by the chemical constitution of the parchment support itself, causing them to become increasingly friable and powdery. Moreover, certain pigments may themselves be agents of flake loss; for instance, lead white, which is often thickly applied and is a brittle paint film, is highly susceptible to flaking; copper green ("verdigris") can become

friable as it reacts with the parchment support; iron-gall ink may also react with uppermost layer of parchment support; medium-rich organic glazes can develop a fine craquelure and sometimes cause the opaque pigment on which they are painted to crack and flake while unglazed areas of the design remain intact.

In short, it is essential to consider all these factors (the type of mechanical damage suffered by the paint layer, the pigments, the media, and the preparation of the parchment surface) before proceeding with a consolidation treatment. Consolidation is never fully reversible, even with good quality materials. As such, considerable care is of essence.

It should be mentioned that gentle humidification and flattening of the parchment support (see 18.4.7 Humidification and 18.4.10 Flattening/Tensioning/Drying) has been used as an indirect method of consolidating the design layer, thereby rehydrating the pigment layer and aiding the medium to "reconstitute" its adhesive power (Yow,; Cains 1982/83). But if the medium is largely degraded, leaving the pigment powdery and friable, humidification may have little effect.

A. Choice of Consolidant

The most prevalent binders used for manuscript paintings and inks on parchment include glair, gum arabic, and isinglass (sturgeon glue), all of which can remain water soluble after drying. With this in mind, the many consolidants that have been suggested and tried by conservators around the world over the last thirty years can be divided into aqueous and non-aqueous consolidants.

1. Aqueous Consolidants: The argument for using a consolidant such as parchment size or gelatin is that they are proteinaceous substances and are similar to the media of manuscript inks and pigment and are more sympathetic to a parchment support than synthetic materials. A water soluble consolidant should be used with extreme care so as not to dissolve water-sensitive pigments, especially organic glazes, and so as not to affect the parchment support.

   Gelatin (powdered photographic grade or leaf gelatin) or parchment size (can be mixed with isopropanol to aid penetration) have been the aqueous consolidants most generally used to treat flaking pigments and inks on parchment. Other possible alternatives include isinglass (as suggested by Petukhova and Bonadies 1993), natural gums, and funori; but these have not been widely tested or used to date on parchment supports. (See 18.3.1 Adhesives and Consolidants.)

2. Non-aqueous Consolidants (See 18.3.1 Adhesives and Consolidants.): Among the many solvent-based consolidants that have been suggested for flaking or friable media on parchment are methyl methacrylate (Cains 1982-83); methyl cellulose in ethanol for powdery matte pigments (Quandt 1992); cellulose acetate; methyl cellulose in methylene/methanol chloride for text inks (Plossi and Crisostomi 1981); Ftorolon, a soluble fluoroplast, for friable pigments (Bykova 1976 and Yusupova 1980); VA 2 EHA, a synthetic resin (an aqueous dispersion of vinyl acetate with 2-ethylhexyl acrylate) for readhering loose paint flakes (Bykova 1976); Plexigum P-24, a synthetic resin (Giuffrida 1983); microcrystalline wax or a mixture of beeswax and

dammar resin (Marconi 1960); soluble nylon (Werner 1974). Many of the following consolidants are not recommended for use.

The arguments for using a solvent-based consolidant are potential reversibility and its lack of dissolving effect on water soluble media; but a solvent-based consolidant can be difficult to control, possibly moving pigment particles in the brush application as the solvent rapidly disperses

B. Local Brush Application

Local application of a consolidant is performed along cracks, within areas of flake loss, beneath lifting paint flakes, and through areas of friable pigment. With a very fine brush (00 or 000) under binocular microscope magnification, the area of loss (along the exposed edges of the paint film) is lightly painted with the consolidant. Capillary action from the liquid consolidant (either from warmed gelatin or parchment size, or from the solvent base in a non-aqueous consolidant) carries the consolidant beneath the paint flake and anchors it to the support.

The setting of the consolidant and firm anchoring of loose paint flakes can be aided by the use of a secondary tool, such as a bamboo or teflon point, or spoon shaped dental tool followed by gently pressing with an interleaving of silicon coated mylar or silicon release paper. For paint layers signifi-cantly softened by the consolidant application, it may be necessary to allow a brief setting period, before pressure is applied to avoid transfer of the softened paint to the release paper. (See Hazards).

Parchment size and gelatin should be applied warm to facilitate penetration and capillary action; but neither should be overheated or they will become denatured and lose their adhesive strength. Extreme care must be taken while working with a local consolidant to maintain a consistent and relatively thin viscosity. The consolidant should not be allowed to become too thick while working (from the evaporation of the solvent or from prolonged heating causing the evaporation of water). If the consolidant is too viscous, the brush will pick up more flakes than it will successfully anchor to the support, creating potentially disastrous consequences. In addition, an excessively viscous consolidant will not flow under the flakes of paint or ink but instead will be deposited on the surface of the media, leaving a shiny residue.

C. Spray Application

The spray application of a consolidant is particularly effective for the treatment of broad areas of flaking or friable design, for instance when a text ink is flaking throughout a manuscript. Fine droplets of the consolidant are delivered by an artist's pneumatic air brush over a broad area of the design and the parchment support. It should be noted, however, that a spray application may not be appropriate for a heavily gilded area, for the consolidant will not penetrate but will remain on the surface of the metal leaf.

1. Without Vacuum Suction Table: The spray application of a consolidant was first introduced in the manuscripts conservation literature to treat not only flaking inks and pigments, but also to soften horny areas and consolidate weak areas of the parchment support (Wächter 1962), using a solution of parchment size, alcohol, and vinegar. (See 18.4.4 Consolidation of Degraded Parchment.) This technique is used in combination with pressing between

blotters, and weights for drying and flattening of the leaves. Particular care must be taken to not over-wet the parchment while spraying, and to use very light weight during pressing so as not to cause offsetting of the pigment layer. More recently this practice has been used in Europe (Wächter 1987) and elsewhere (CCAHA, Philadelphia) without the addition of vinegar in the consolidant solution. The use of B-72 in di-ethylbenzene has been recommended as a spray consolidant for powdery matte paint on wooden ethnographic objects (Welsh 1980), but has not been applied to inks and pigments on parchment to date.

2. With Vacuum Suction Table: By combining the spray application of a consol-idant with the use of a vacuum suction table, three results are achieved simultaneously: a) the parchment support is held under light pressure, and is thereby kept flat and in plane during treatment; b)the parchment support dries quickly and is not allowed to stay damp long enough to cause dimensional change; c) loose paint flakes are anchored immediately to the support by suction during treatment. The treatment of single parchment leaves employs a traditional vacuum suction table (Quandt 1986; also Maggen 1991), while the consolidation of flaking inks and pigments within a bound manuscript employs a wedged-shaped vacuum suction platen, first described and designed by S. Michalski for in-situ book repair (Quandt 1991). Care must be taken especially for works with design on both sides of the parchment support: the amount of suction should be carefully controlled and monitored so as not to pull loose inks off the verso or underside of the support during treatment. This can be avoided by briefly pre-treating the verso or underside of the support with spray consolidant before moving to the suction vacuum table. (Quandt 1991.)

D. Applied as an Ultrasonic Mist

Designed and developed by Stefan Michalski (1990) of the Canadian Conservation Institute, the ultrasonic mister delivers the consolidant as a very fine mist (1/10th the size of droplets from a pneumatic airbrush or spray gun), providing greater control and more effective penetration of the pigment layer. The mister was developed for consolidating powdery, binderless paints (as on ethnographic objects), has been applied to the consolidation of pastel and other media on paper artifacts (Weidner 1993). The technique has not yet been applied to media on parchment, but offers great potential for reducing some of the difficulties of a spray treatment. (See 18.4.3 Consolidation of Media.)

E. Hazards

1. Mechanical Problems Affecting Design: Flake loss to an already fragile design can be aggravated during the course of a consolidation treatment, either by local application with a brush or by using a spray on the vacuum table. Moreover, if the consolidated area is pressed too soon after treatment while the consolidant or pigment medium is still wet, or if too much pressure is applied, offsetting and irreversible deformation to the surface texture of the design can occur.
2. Changes in Appearance of Pigments: The visual appearance of the design layer can be irreversibly damaged by an over-application of consolidant by using

brush or spray. For instance, an aqueous consolidant could re-solubilize the pigments during treatment; a consolidant could saturate matte colors and change its reflectance; an overly liberal application of consolidant could change surface gloss of pigments; and too much solvent or too aggressive a solvent could carry pigment particles away from their boundaries, causing a halo effect, or drive the pigment into the fibers of the skin. In addition, the suggestion has been made (Fuchs 1991) that many organic colorants and inks used in manuscript paintings are pH sensitive and may be adversely affected by the pH of such consolidants as gelatin and parchment size, but research into this question has not yet been made available to conservators. Ultramarine is known to be pH sensitive and can be dissolved by acetic acid. (Gettens and Stout p.166.)

Depending on the recipe used gelatin or parchment size can vary widely in their pH. An adhesive made from unrinsed parchment clippings will contain more alkaline calcium compounds, and a higher pH, than one made from rinsed parchment. Gelatin usually has a mildly acidic pH of about 5.5. If acetic acid is added to gelatin it's pH will fall below 5.0. Acetic acid will also lower the pH of parchment size, but not to the same extent as with gelatin.

3. Changes to the Parchment Support: An overly liberal application of a consolidant could leave visible residues on the surface of the parchment support as well as change the surface characteristics of the skin. Moreover, if the consolidant is allowed to over-penetrate the support and is then weighted with too much pressure, the parchment could become darkened or even translucent in some areas. One question that has yet to be studied is whether the application of a consolidant to selected areas of a sheet of parchment will cause differential tension between treated and untreated areas of the skin.

4. Problems with Unstable, Damaging, or Irreversible Consolidants: The past uses of such unstable and irreversible consolidants as soluble nylon or cellulose nitrate (See O. Wächter discussion of "Zapon varnish," 1982) provide cautionary evidence of the potential hazards of media consolidation. Moreover, the question of reversibility is a particularly vexing one with regard to the consolidation of media on a parchment support: such aqueous consolidants as parchment size and gelatin are obviously irreversible when used on the water-soluble media found in manuscript text inks and illumination; but the reversibility of solvent-based consolidants is also a question if certain solvent treatments are potentially damaging to the collagen structure of the support. (See 18.2.5.G Problems Caused by the Use of Organic Solvents and 18.4.5 Solvent Treatments.)

18.4.4 Consolidation of Degraded Parchment

Mold can be particularly damaging to parchment, causing severe staining of the skin and general breakdown of the collagen fiber structure. In cases of light to moderate mold attack the the parchment may appear pock-marked, with small depressions in the surface of the skin and associated areas of staining. In severe cases the entire thickness of the skin may be degraded so that it appears very fibrous and pulpy and has no mechanical strength. It is rare for the entire surface of a parchment artifact to be damaged by mold; usually the damage is more localized and limited to areas that have

been especially damp such as the edges and corners of single sheets. Particularly interesting examples of mold attack have been seen in a group of illuminated parchment manuscripts that once belonged to Mathias Cornivas, the 16th century King of Hungary. These manuscripts were stored at one time in very damp conditions and in many cases the mold attacked only the blank areas of parchment and avoided the text which was written in a type of iron gall ink. (The examination and treatment of these manuscripts is described in a series of articles by Boethy-Kozocsa 1987).

Parchment that has been affected by mold is much more prone to mechanical damage, due to the extreme weakening of the fiber structure. In addition, these areas can easily darken with the use of aqueous adhesives during the process of repair. The process of consolidation can usually help to strengthen weak and perforated areas of the original parchment. In addition consolidants can sometimes act as "sizing agents" by filling in the loose fiber structure, thus making it possible to use aqueous adhesives for the attachment of mends without causing staining or discoloration of the support. When the mold damage occurs in relatively small areas consolidation can be carried out locally using a brush. Otherwise it is necessary to apply the consolidant in spray form for the treatment of more extensive areas of mold damage. These and other techniques are described below.

A. Local Brush Application

Anthony Cains has developed a local consolidation technique using a dilute solution of Klucel-G in ethanol which is applied to the area of degraded parchment with a brush. The Klucel seems to penetrate well into the skin and does not cause any obvious discoloration of the affected area. (In the case of extremely degraded skin, however, darkening has been observed with the use of Klucel solutions in ethanol, isopropanol and acetone. For these reasons small areas should be tested with any consolidant prior to use.) (AQ) Cains has found that the Klucel-G acts as a type of sizing agent for the degraded skin which permits him to apply a repair with gelatin without causing the type of darkening that occurs with the use of aqueous adhesives. A similar technique employs carboxymethyl cellulose in an alcohol (?) solution for the local consolidation of mold damage on a fatty sheepskin parchment. (PY)

B. Spray Application

1. Without a Vacuum Suction Table: Several conservators have applied a variety of adhesives in spray form, without the use of a suction table, for the overall consolidation and strengthening of mold-damaged parchment. Otto Wächter's recipe for parchment size, which contains one third size, one third wine vinegar and one third alcohol (see 18.3.2 Lubricants), has been described in the literature as serving many purposes from the consolidation of flaking media and the strengthening of degraded parchment to the lubrication of parchment that is stiff and horny from water damage. In each case the parchment size solution is applied in the same way, by lightly spraying the entire surface of the artifact using an air brush or spray gun. Although the wine vinegar in the solution is reported to evaporate relatively quickly, and not cause any obvious damage to the support or the media, some individuals have argued against its use, saying that it might cause a color change in certain pH sensitive pigments (Fuchs, 1991). In

Hungary conservators at the Szechenyi National Library have recently used a so-called "regenerative spray" for the consolidation of severely mold damaged parchment. This solution, which is applied with a spray gun over the entire surface of the manuscript leaf, contains 2% Preventol CMK (a fungicide), 2% Klucel-M and 96% ethanol. (Szlabey 1992, p.585.)

2. With a Vacuum Suction Table: The spray consolidation of a degraded parchment artifact can be aided in many ways by the use of a paper suction table. The suction holds the object in place during treatment and allows for a more effective penetration of the consolidant into the skin. Cockling that would otherwise occur with the application of an aqueous consolidant is kept under control and the skin stays relatively dry and free of distortions as a result. Noticeable alteration of the color and surface characteristics of the skin, which could easily occur with the use of aqueous consolidants, is generally avoided when a suction table is employed. Two similar methods of spray consolidation have been described by Quandt (1986 and 1992) whereby flaking ink and/or mold damaged parchment were treated. In the first case the manuscript had been disbound and it was possible to treat single leaves and bifolia on a standard paper suction table. In order to achieve optimum penetration of the consolidant, and also to relax the flaking ink that was found on many of the degraded leaves, the parchment was humidified under Gore-Tex prior to treatment.

   In addition, a simple humidity chamber was constructed over the suction table so that ultrasonic mist could be introduced during the course of treatment. While the manuscript leaf was held in place on the suction table an extremely dilute solution of parchment size in water and ethanol was applied to the surface of the skin using an air brush. Since it was not possible to tell how much penetration of the consolidant was achieved, both sides of the damaged leaves were treated with approximately five light applications of parchment size to each side. Following treatment there was no obvious change in the color or surface appearance of the parchment and the degraded areas of the skin felt noticeably stronger as a result of the consolidation treatment. In the second case history published by Quandt (1992) the manuscript suffered only from flaking ink and had not been damaged by mold.

   However, the same system of spray consolidation that was devised for this manuscript was more recently employed for another bound volume which had suffered greatly from mold attack. Since neither book could be disbound for treatment, consolidation was carried out in-situ, using a book suction device that was originally designed by Stephan Michalski of the Canadian Conservation Institute. Once in place on the suction platten the manuscript leaf was first sprayed with ethanol and then with a dilute solution of parchment size in water and ethanol. The two sides of each leaf were treated with a fine spray of the consolidant approximately five times, with a brief waiting period in between applications in order to avoid over-dampening the parchment with the aqueous adhesive.

   In both cases the consolidation achieved its desired effect, without altering the color or surface characteristics of the parchment in any noticeable way.

Following spray consolidation of the mold damaged manuscript it was then possible to carry out the repair of tears and perforated areas in the leaves. However, the parchment was still extremely susceptible to water-based solutions and aqueous adhesives such as gelatin and starch paste caused noticeable darkening of the skin. For this reason repairs were largely carried out using a Japanese tissue, pre-coated with Klucel-J, which was activated with either ethanol or acetone. (See 18.4.11 Mending and Flattening.)

C. Hazards

There are many potential hazards in the consolidation of mold damaged parchment. Depending on the type of adhesive that is selected, and the way in which it is applied, the chances of altering the color and surface characteristics of the parchment are considerable. Since consolidation is essentially an irreversible process one must also consider the ageing characteristics of the chosen adhesive and how it will react with the parchment support over time. The effect of the consolidant on any media that are present must also be considered, especially if the degraded parchment is consolidated overall rather than locally. Possible damage to media can include the alteration of pH sensitive paints, saturation of matte colors, and deposition of consolidant on the surface of media which could later lead to cracking and flaking.

18.4.5 Solvent Treatments

A. Pressure-sensitive Tape Removal (See AIC/BPG/PCC 15. Hinge, Tape, and Adhesive Removal.)

Heat is generally not suitable for removing pressure-sensitive tapes and adhesives. (See 18.2.5.D Problems Caused by Use of Heat.) Purely mechanical methods of removal may be preferred for tapes on hard, smooth parchment surfaces. Sometimes, however, organic solvents will be needed. Because of the hazards to parchment of solvent use see (18.4.5.F), organic solvents should be used in as limited a fashion as possible. Therefore, pressure-sensitive tapes will often be removed using sparing direct application of solvent with a brush to soften the adhesive combined with mechanical removal as forceful as the condition of the artifact will permit. A rubber cement pick-up eraser (crepeline) and/or a dull knife can be used for this purpose. Exposure to organic solvent will not soften parchment the way humidification does, thereby rendering it less vulnerable to mechanical damage. Of course, parchment that is very degraded, mold-damaged, or prepared with delicate surface coatings can withstand very little mechanical stress and may require more reliance on solvent activity or may make tape removal too damaging to undertake.

Parchment with pressure-sensitive tapes can be exposed to solvent fumes in a closed solvent vapor chamber in order to soften the adhesive and facilitate mechanical removal. A vapor chamber could conceivably alter parchment or media, but at least it does not entail the risk of solubilizing and "washing out" constituent materials. The first step in carrying out this treatment is to test the adhesive directly with solvents to find one that softens the adhesive or makes it tacky. Where large amounts of tape are involved it may be necessary to return the

parchment to the solvent chamber several times to resoften the adhesive in the course of mechanical removal.

Pressure-sensitive tapes can also be removed with the aid of local exposure to solvent vapors. For example, a deep petri dish could be filled with plaster, which is allowed to harden, saturated with the appropriate solvent, and then inverted over the area to be treated. Solvent poultices could also be tried (see below) and for alternatives to the use of organic solvents see 18.4.1. Cleaning Methods.

B. Removal of Accretions and Adhesive Residues

See above, A. Removal of Pressure-Sensitive Tapes. Also, for alternatives to using organic solvent, see 18.4.1 Cleaning Methods. Beware of removing accretions that might provide evidence of historic use, such as candle wax drippings.

When prolonged exposure to solvent is required, a solvent-based gel called Carbopol may be useful as a poulticing material. According to Wolbers "Carbopol is B.F. Goodrich's trade name for a series of polyacrylic acid polymers typically used as gelling agents in pharmaceuticals and cosmetics." (Wolbers 1990, pp.149-150). Carbopol resins are manufactured in a variety of molecular weight sizes and purities and are quite versatile in that they can be prepared in many different solvents.

C. Removal of Laminations, Dry-Mount, and Heat-Set Tissue

Heat is generally not suitable for removing thermoplastic backing adhesives, because of the hazards heat poses to parchment. (See 18.2.5.D Problems Caused by the Use of Heat.) Purely mechanical methods of removal may be preferable for smooth, hard parchment surfaces. For removal of dry mounted parchment. (See 18.4.2 Removal of Previous Restorations.) In many cases, however, organic solvents are needed. As with pressure-sensitive tapes, solvents may be applied sparingly with a brush to soften or swell the adhesive and then the lamination or backing can be removed mechanically with as much force as the condition of the parchment will permit. Backings can also be exposed to solvent fumes in a vapor chamber to facilitate mechanical backing removal. It may be necessary to return the parchment to the solvent chamber several times in the course of backing removal in order to resoften the adhesive.

When very degraded parchment has this type of backing, the parchment may be unable to withstand any mechanical activity, and a solvent bath may be considered. The hazards of this drastic treatment must then be weighed against the benefits of the backing removal, and the decision may be made to leave the backing undisturbed. Even if the backing can be successfully removed, if the adhesive can not it can cause problems because of an exposed sticky adhesive layer, or because a hardened adhesive layer might cause cockling when it is not restrained by the backing. As always the benefit of the treatment must be weighed against its costs. (See 18.4.2 Removal of Previous Restorations.)

One particular case is the treatment of manuscripts that were laminated in the 1950's with a glued or heat-set PVC film called "Mipofolie." Workers in both Germany and Belgium have reported success in delaminating important illuminated codices in a bath of 1/4 amyl acetate/ethanol. They did not feel that

the solvent bath had any negative effect, except for a possible migration of a small amount of adhesive into the parchment structure in the case of one sheet. Their greatest concern after removing the film was to make sure that no sticky adhesive residues remained on the surface, and some clean-up of such residues was necessary after each bath. The efficacy of the bath was speeded up by both mechanical lifting of the edges of the films, and by piercing the film with a needle in problem areas. In both cases the leaves were immersed briefly, just long enough to permit mechanical detachment of the film with slight effort. (Wouters et al. 1990, and Wächter 1987.)

D. Removal of Lubricants

Sometimes parchment is lubricated overall with organic materials such as petroleum jelly, lanolin, oils, or other widely varied substances in a misguided attempt to "nourish" or "condition" the parchment, similarly to the way leather used to be routinely treated. Many of these lubricants are damaging to parchment, as they can darken the skin and/or leave a sticky residue on the surface which traps dirt and contaminates materials with which it comes into contact. It is certainly desirable to remove these lubricants whenever possible, and to the extent possible. This generally means either wiping the entire surface with cotton dampened with organic solvent or, rarely, immersing the artifact in a solvent bath. Certainly the former approach subjects the item to less risk from exposure to solvent, while entailing greater risk from abrasion of the surface. Another possible approach is to press a series of papers or blotters wet with the appropriate solvent on the surface of the artifact to wick away the lubricant. The paper should not be allowed to dry in contact with the parchment surface, to avoid the danger of its becoming adhered. It is not possible to remove every trace of lubricant from parchment, and the hazards involved in the chosen treatment should be weighed against its benefit. It may be wiser in some cases to settle for removing only enough lubricant to eliminate the stickiness from the surface.

E. Reduction of Stains

Poultices and the suction disk will occasionally be helpful in reducing localized oily stains. A poultice of Fuller's earth dampened with solvent was very effective in reduction of darkened, oily stains.

F. Hazards of Solvent Use (See 18.2.5.G Problems Caused by Use of Solvents and Ellement 1987.)

18.4.6 Bleaching

The reduction of stains in parchment with bleaching agents was occasionally practiced in the past by some conservators. Otto Wächter (1962 p.165) reported that chlorine is ineffective as a bleach for parchment and also quite dangerous, as the parchment turns darker rather than lighter as a result of the interaction of the bleach with the protein in the skin. However Wächter found that a dilute solution of hydrogen peroxide could be used for the local bleaching of spots caused by mold, blood, ink and fly specks. His recipe called for 30% hydrogen peroxide to which a few drops of ammonia are added. The area of discoloration on the parchment is dampened with water and then exposed to the hydrogen peroxide vapors from the bottle. If the desired amount of bleaching is not achieved a greater portion of ammonia can be added to the bleach. The direct

application of hydrogen peroxide was not recommended by Wächter since he found that it would decompose the parchment.

More recently, further research on the effect of bleaching agents on parchment has been conducted by Claire Chahine and Dominique Rouy at the Centre de Recherches sur la Conservation des Documents Graphiques in Paris. Their initial report (1993) has confirmed Wächter's statements about the negative effects of chlorine bleaches, particularly Chloramine T, on parchment. They found that it is impossible to completely eliminate the residual chlorine from the skin, even after treatment with an anti-chlor of borohydride or sodium thiosulfate. Rinsing with running water was out of the question considering the damaging effects that it would have on the parchment. The use of hydrogen peroxide as a bleaching agent was then considered by the authors. They found that any metal ions in the skin (especially copper and iron), even if present in minute quantities, would react with the bleach and cause the protein to depolymerize and the parchment to eventually dissolve. EDTA was then tested for use as a complexing agent for the metals in the skin, in the hopes of avoiding the type of reaction that had been observed earlier. Although the EDTA seemed to work quite effectively the entire bleaching treatment required a total of two hours. There were also many other concerns about the mechanics of the process and the effect that it would have on an old parchment artifact. Although research into the question of bleaching parchment is being continued by these authors there is strong indication from their initial results that this is not an appropriate treatment for conservators to undertake on original material.

18.4.7 Humidification

Parchment must be humidified in order to make it responsive to any flattening/tensioning/drying treatment which follows. This is most often done in order to reduce the distortions in a skin. Markedly cockled, shrunken, or puckered skins can be difficult to read and visually disturbing. They are also subject to increased abrasion, which is a particular concern in cases where the sheets are in direct contact with each other as they are in a book or in a multi-sheet document. The improved flexibility of skins that have undergone this treatment contributes to their safety in storage, housing, and handling. Also, sometimes it is necessary to humidify a skin in order to make it possible to join a tear in a distorted area.

Humidification should always be carefully controlled and monitored, and not carried beyond what is necessary. Some conservators monitor the water content of the skin with a surface electrode before, during, and after humidification and also during drying. (Aqua-Boy, Sovraign and the Digital Mini Protimeter from Museum Services are three brands currently in use). Most conservators, however, rely on visual observation and manual testing of the flexibility of the skin in order to decide when the humidification is sufficient. Over-humidification can lead to permanent alteration of the skin, surface preparation, or media (see 18.2.5.A Problems Caused by Water or Excessive Moisture) and can make the skin much more susceptible to damage during pressing or tensioning (see 18.2.5.B and C.)

Controlled drying, using one of several techniques described in 18.4.10 Flattening/Drying/Tensioning, must always follow overall humidification. If the parchment is allowed to dry unrestrained, it will certainly cockle, and will probably be permanently altered. As an alternative to overall humidification, sometimes tears

needing repair and isolated distortions can be locally humidified and dried. (See 18.4.9 Local Treatment.)

The method chosen for humidification should take into account many factors, including the type, thickness, and condition of the skin, surface preparations, media, the goal of the treatment, and the quantity of material to be treated. Before beginning humidification it is important to consider what drying method will be used and have all tools and equipment ready. A delay may cause an artifact to become overly hydrated or to dry too quickly.

A. Humidification Chambers

Humidification chambers are designed to expose parchment artifacts to water vapor in a closed environment (Weidner 1993). The time necessary to hydrate a skin depends on many factors, including the quantity of material in the chamber, the type, thickness, the condition of the skin, and the design of the chamber. The process should be slow, to allow even, overall expansion. Cains (1982) suggests "85-95% RH in the humidification chamber, to achieve a moisture content in the skin of 22-28% for initial tensioning and 15-20% for final flattening and repair." (See Forde 1986, p. 39.) There are not, however, firm guidelines which dictate the level of moisture required in a chamber, since different types of skin or areas of a skin (such as deteriorated areas of mold-damaged skin) absorb moisture at different rates. The humidification process should be monitored closely to guard against over humidification, and to ensure that condensation does not form inside the chamber causing moisture to drip onto the artifact, where it could damage the media, the surface preparation, or the parchment itself. Many conservators place an additional protective layer such as Gore-tex, polyester web and/or a blotter on top of the parchment in order to guard against this hazard. If glass is used to cover the tray, it can be pre-wiped with a treated cloth, designed to prevent condensation on the interior of windshields. Extreme caution is needed when humidifying mold-damaged skin, and a faster humidification method such as the "damp pack" (see below) may be safer.

1. Covered Tray
    a. With Damp Blotters: Damp blotters line the bottom of a deep tray. The object (which is sandwiched between polyester webbing) is suspended over the blotters on a permeable and non-wicking material such as a light diffuser panel or a plastic screen. A damp blotter on top of the sandwich will accelerate the humidification process, if desired. The tray is then covered with Plexiglas in order to create a closed environment.
    b. With Water: A tray of cold water can be placed in the bottom of a larger tray. The object is suspended above the smaller tray on a rigid permeable support such as a light diffuser panel or a stretched plastic screen, and the larger tray is covered with Plexiglas to close the chamber.
    c. With Saturated Salt Solutions: With a saturated salt solution, the humidity in a chamber can be set to a very specific level.
2. Gore-Tex Systems

    The very small pore size of the Gore-Tex laminate allows only water vapor to penetrate through to the skin (see Purinton and Filter, 1992). However,

Gore-Tex is a fragile material and the user should take certain precautions. Through time and use, minuscule breaks or punctures can occur in the fabric, thereby allowing more moisture to pass in that particular area. To locate these areas of concern, the conservator should carefully examine the material before using by holding it up to a light. The weak or perforated areas will allow the light to pass through. To prevent accidental leaks either a second layer of Gore-Tex or polyester interleaving should be used. As with any humidification technique it is important to have the flattening and drying materials prepared in advance and to work quickly during tensioning because some conservators feel that parchment humidified with Gore-Tex dries faster. (Singer 1992.)

a. One-Sided Humidification: The Gore-Tex is laid on the artifact with the Teflon side down, and the felt side away. The usual moisture source is a damp blotter laid on top, although water could also be sponged or sprayed directly on the felt side of the Gore-Tex. For added protection a polyester web can be placed between the artifact and the Gore-Tex. A light weight, such as a felt or sheet of Plexiglas, can be laid on top of the package to help keep the layers in contact with each other. This weight should be minimal to avoid forcing excess moisture through the Gore-Tex, endangering the artifact.

   This method of humidification offers increased control and is useful for treating single objects, and those with particularly sensitive media when it is desired to reduce the exposure of the recto to moisture. This method is preferable to humidifi-cation methods that utilize pressure such as a damp pack for objects with painted or gilded surfaces. Gore-Tex has been used successfully to humidify attached, multiple sheets such as charters which cannot be separated, isolating the adjacent sheets from the moisture with polyester film. It can also be used for humidifying individually skins which are joined to compose a larger sheet. Small pieces of Gore-Tex can be used for local humidi-fication within a sheet. (See 18.4.9 Local Treatment.)

b. Two Sided Humidification: Two-sided (sandwich) humidification can be used for faster and more thorough humidification of a skin, by placing Gore-Tex and interleaving layers both above and below the object. To make a sandwich, place the dampened Gore-tex (felt side down/smooth side up) on a waterproof table surface. For added protection, layer thin Gore-tex and polyester interleaving, then object, multiple sections, etc., more interleaving, thin Gore-tex and then the dampened Gore-tex (felt side up, smooth side towards object). Cover all with Mylar or polyethylene sheeting and weight edges to "seal" humidity. For objects with sensitive media there is minimal weight and pressure. If the object(s) can withstand more contact, drape sandwich with 1/2" or 3/4" felts.

3. Damp Blotter Pack

Sheets of blotting paper are soaked in water and then drained. They are then interleaved with dry blotters of the same size and pressed under firm weight until moisture is evenly distributed throughout the pack. No liquid

water should be present. The artifact is sandwiched between two pieces of polyester web and then inserted between two or more sheets of damp blotter on each side. The package is put between pressing boards and under moderate weight for less than five minutes. The object is then taken out and checked for its state of humidification. If it is not sufficiently limp it may be returned to the damp pack for another few minutes; otherwise it is removed (still between polyester web) and placed between dry blotters and pressing boards for drying/flattening (see 18.4.10. Flattening/Tensioning/Drying).

This method can be adapted for use with multiple items by stacking up additional damp blotter, interleaving and parchment sandwiches in the pack. It is not suitable for severely distorted sheets which could crease under moderate weight or for leaves with significant media. (See Cains,1982/83.)

4. Roll Pack: This method has been used in Record Offices of the U.K. and is described by Cains (1982/83). The object is placed between polyester web and then rolled in dampened fabric or blotters and placed in a sealed plastic tube or bag.
5. Trash Barrel: This technique is often used for oversized and rolled artifacts. A small plastic trash barrel is placed inside a larger barrel which is lined with damp blotters. The artifact, protected by polyester web, is placed in the center of the smaller trash barrel and then the top is covered with a tight-fitting lid. Metal barrels are not used to avoid the risk of metal contamination.

B. Moisture Chamber with Ultrasonic Humidifier

Ultrasonic humidifiers generate a mist of very finely dispersed water droplets, in contrast with traditional humidification systems which expose artifacts only to water vapor. Therefore this system is a bit more hazardous to very water-sensitive media and mold-damaged skins. There is also an increased danger of condensation on the surface of the artifact, and on the interior of the chamber, where it could eventually condense and drip onto the surface of the item. Ultrasonic humidification does, however, quickly and conveniently produce a humid environment in a chamber, and is a popular method for humidifying a wide variety of materials, including parchment. (See Weidner 1985.) Museum Services Corporation will, in the near future, be marketing a new version of Marilyn Weidner's humidity chamber.

Ultrasonic mist is introduced into a chamber, such as a suction table dome or a covered sink. Some conservators let mist fill the enclosure and then place the objects in the chamber. Others prefer to place the objects in the chamber and then introduce the moisture. A good moisture chamber can be constructed by the conservator, as elaborate as the available tools and skills permit. Polyethylene can be draped over a deep sink or simple wood framework for a very simple chamber.

1. Enclosed Rack: A free-standing drying rack (often a modified Baker's rack) can be used as a mass treatment chamber for humidification of parchment items. The rack is enclosed with polyethylene sheeting. For access during use the polyethylene is draped in such a way as to create a curtain door. To

prevent moisture from escaping at the base of the rack chains or book snakes are used to hold the sheeting against the floor. An ultrasonic humidifier and hose attachment is used to introduce moisture an any desired point. One common method is to set the humidifier up outside the chamber (for control and refill convenience) with the hose inserted at the top of the rack. A small fan placed inside near the point of moisture entry will help speed distribution. As in other humidification techniques, the parchment is sandwiched between interleaving before being placed on the rack.

A collapsible clothes line draped in polyethy-lene sheeting is sometimes used for folded sheets, such as book pages, that can be draped over the lines.

2. Lauscaux Chamber: The Lascaux chamber developed and described by Olivier Masson, which is available commercially from Lascaux Restauro, incorporates ultrasonic humidification. A desired humidity level can be achieved and maintained over long periods by means of an external humidistat.

C. Moisture Chamber Using Steam and/or Ultrasonic Mist

1. Clarkson Conditioning Chamber: Christopher Clarkson has designed a system which performs three functions: 1) humidification, 2) drying by drawing air over a refrigeration system, and 3) introduces heat if required. The moisture is provided by one of two methods: by steam which is cooled before it enters the chamber or by ultrasonic transducer which is a plug in unit added to the chamber. Both are controlled by a humidistat. This system allows a great deal of control. It has sufficient capacity for numerous objects to be humidified simultaneously, and direct observation of the objects is possible. The objects can be held in a relaxed steady-state while awaiting tensioning and drying. (See Clarkson 1982.) This chamber is not commercially available.
2. Hotpack Humidity Test Chamber: The Hotpack Humidity Test Chamber is a commercially available chamber which is made by the Hotpack Corporation (Philadelphia, PA). It is currently used at the New York Public Library for the humidifi-cation of parchment documents and bookbindings. The moisture source is steam from an external vapor chamber which is connected to a water supply.

D. Applications of Alcohol and Water (See 18.2.5.G Problems Caused by the Use of Organic Solvents.)

1. Immersion: Alcohol or alcohol and water baths have been used for separation of multiple blocked pages or sheets which cannot be pried apart (ie. dry flood damaged material covered with mud.) The alcohol penetrated the skin and mud and reportedly resulted in even relaxation. (Giuffrida 1983.)

   The advantages of this approach must be weighed against the hazards of solvent use. This is a drastic method which should probably be reserved as a last resort.
2. Spray Application: Some conservators have used spray application of 60/40 ethanol/water to achieve quick humidifi-cation/relaxation of parchment. This is not a gradual technique and it may not hydrate evenly. It might be

resorted to in field situations for quick relaxation and inspection of distorted archaeological specimens where time and equipment are limited. It can also be useful for prolonging the relaxed state of parchment which has first been humidified in a chamber, but which requires prolonged manipulation and incremental local flattening. (See 18.4.9 Local Treatment.) When this sort of flattening is laborious and time-consuming the conservator may not wish to return the artifact to the humidity chamber when it is almost dry but only partly flattened, possibly undoing the improvement that has already been gained. (Dreibholz 1983.)

Sometimes tensioning a parchment that is severely distorted or over-sized may also turn out to be a lengthy procedure. This is another case when spray application of alcohol/water may be needed to prolong working time, especially if the conservator is working in a dry environment. Spray application would not be appropriate for a napped surface or on vulnerable media. The use of alcohol solutions does entail the risk of dehydrating the skin and perhaps causing structural damage, so it must be used moderately and carefully.

E. Hazards

The nature of parchment is due in part to its method of manufacture, see 18.2.3. The parallel orientation of the fiber bundles that takes place during manufacture (by drying the skin under tension) makes parchment especially vulnerable when exposed to moisture. If left too long in the humidified state the fibers begin to realign themselves causing permanent and often radical planar alterations. Skin humidified too long can also become so soft that any tensioning can cause over stretching, deformation, and other unacceptable dimensional changes. Permanent damage may also occur if parchment is dried improperly. These hazards are noted in the various drying techniques in section 18.4.10. However, there are damages which can occur during humidification and before drying.

If a skin becomes too wet, it can become irreversibly translucent in areas, and if it is seriously degraded, as in the case of mold-damaged skin, degraded areas can gelatinize. Overly wet skin can become translucent under the pressure of a damp pack, as well as when pressed for drying. Skin left in the humidified state too long is susceptible to mold attack.

In enclosed chambers with standing water, steam, and/or ultrasonic mist condensation can occur both on the artifact and on the interior surfaces of the chamber where it can condense and drip onto the artifact, causing permanent damage to skins, media, and surface preparations.

Paint layers and other media may be softened by humidification, and these media can offset when they are in contact with blotters, screens, polyester web, and the like in humidification sandwiches and damp packs. Binder layers beneath paints can expand causing media to crack or flake, and flaking media can dislodge. (See Clarkson 1992.) Faint markings which contain bibliographic or paleographic information can be lost, and surface preparations involving glazes, grounds, and pumicing can be altered.

Some thin skins have a tendency to curl when they are humidified, and this can disturb sensitive media and surface preparations, and can cause tears in weak areas to lengthen. The tendency to curl may be so persistent that it is problematic to place the item under any restraint or weight without pressing curled-in areas.

All materials such as blotters, screens, and protective sheeting which come in contact with parchment under humidification should be clean and free of mold and metal (other than stainless steel) to avoid contamination.

18.4.8 Lubrication of Horny, Desiccated Parchment

At one time the lubrication of parchment was a widely accepted practice and the rationale for this treatment was often presented as follows: "The most widely spread damages of parchments are different kinds of deformations. This is precisely why the main attention in restoration practice is paid to softening and straightening, that is, the elimination of deformations". (Yusupova 1980, p.57.) The proteinaceous natural glue component of the processed parchment sheet, which cements in place the fibrous structure, was thought to become brittle over time and the natural plasticizing or grease component of the "glue" to become ineffective so that parchment lost its strength and flexibility. (Wächter 1962, p.23.) Lubrication met two needs of such deteriorated parchment: the softening of brittle sheets and the regeneration of the parchment size.

Lubrication has also been used as a preventive procedure. By coating the fibers of the dermal network with oils and fats which are "hydrophobic, soft and easily sheared" its water resistance is enhanced and its variability with changes in ambient environmental conditions, a result of its inherent hygroscopicity, is reduced. (See Reed 1972, pp.1 70-171; Vinas 1975, p.111.) Lubrication may have been inspired by practices recorded in medieval recipes for preparing parchment. Many fats listed there are fairly polar lipids which can bind small but definite amounts of water to provide the basis of parchment handle and flexibility while minimizing absorption of excess water vapor and the subsequent risk of biological decay. (Reed 1972, pp.170-1.)

The uncertainty surrounding lubrication may account for the many recipes found in the conservation literature, "each claiming to be excellent and universally applicable". There is confusion also because it has been assumed that "what is permissible with leather is also feasible with parchment...In fact parchment requires very little in the way of fatty substances to improve its handle...". (Reed 1972, p.236.)

More recently the practice of lubrication has been largely abandoned in favour of water-based softening systems. Since parchment relies for much of its flexibility and general handle on its moisture content, it is the loss of water, not oils and waxes, that is largely responsible for parchment's loss of flexibility and its embrittlement (Clarkson). Instead of lubrication, the literature now concentrates on methods of returning optimal moisture content to the skin and its sufficiently even distribution in the parchment. It is recommended, therefore, that the conservator first try the hydration and flattening methods described in 18.4.7., 18.4.9 Local Treatment, and 18.4.10. If these methods are not successful, as may be the case with severely distorted and shrunken material, some of the methods described in this section may be resorted to as long as their inherent risks are clearly understood. Carefully test all constituents prior to application of any lubricant.

Another reason why these methods have been abandoned is a change in preservation philosophy: "Techniques and materials that change the original character of the [object], such as impregnation with synthetic polymers, humectants, plasticizers or lubricants are...not necessary if the storage or exhibition environment is stable and controlled (55-60%) the equilibrium moisture content of the material maintained at the correct level to keep it flat and pliable." (Cains, 1992)

A. Polyethylene Glycol (PEG)

Used in Madrid for the lubrication of horny parchment and also for general relaxation of cockled parchment; the most useful and preferred is PEG 400. (See Vinas 1979.) Carbowax has been used in molten form to separate leaves of a heat-damaged parchment manuscript. It has also been used in combination with lubricants, e.g. gelatin and glycerol,to relax brittle, desiccated parchment. (Werner 1974, pp.17-18.) Moderate success was achieved by brushing PEG 200 on a distorted, heat-damaged parchment tensioned on a strainer to investigate the potential of simultaneous softening and tensioning. (Tanasi 1984, p.23.) Useful where inks are unstable in water and alcohol solutions.

An experimental technique using PEG was recently developed by Dag Ernst Peterson for the treatment of a severely water-damaged parchment book. The technique itself was developed by Vinas (Spain) and recommended to Peterson by Prof. Alicja B. Strzelczyk, Kopernikus University, Torun, Poland. Mr. Peterson's experimental work was to modify the Polish procedure for treatment of the Theuerdank, a 16th printed book on parchment that had been severely damaged by water. His new technique is based on the idea of introducing PEG into the skin in a very controlled manner, rather than using the more liberal quantities that are recommended by Vinas. The vellum leaves were transparent and stiff from the water damage and the original napped surface was flattened. With a defined sequence of applications separate solutions of calcium hydroxide in water and polyethylene glycol were applied indirectly to the parchment. The leaves were then dried under tension using C-clamps. The timing was critical for each treatment and varied depending on the condition of the individual leaf. The treatment was successful in making the vellum opaque and flexible and in recreating the original velvet nap of the skin.(DEP)

B. Urea, With or Without Spermaceti Wax

10% urea in ethanol and water was applied to surface of a parchment document through tissue paper so the inks would not be disturbed or softened. Reduced folds and creases effectively (O'Hoski 1976, p. 67, see also her note 6). Moisten parchment thoroughly with above or dip it in its 5-10% solution, then simultaneously dry and press. After partial drying Yusupova 1980, p.58, recommends additional greasing treatment with 1-2% alcoholic benzol suspension of spermaceti wax (alcohol-benzene spermaceti emulsion).

C. Parchment Size With Wine Vinegar and Alcohol (see 18.3.2.A)

D. Leather Dressing

Pliantine proved to be more suitable for relaxing the parchment components of Javanese shadow puppets than either British Museum Leather Dressing and

neatsfoot oil. After application, excess Pliantine was not removed for several months to ensure good penetration. Then the surplus was removed with solvent (hexane, petroleum ether). Impregnation caused temporary slight darkening of applied colours (Gowers 1975, pp.4-5).

E. Glycerin (see 18.3.2.E.)

F. Alcohol

1. Methanol: Giuffrida describes the successful use of methanol, in a bath or as a vapor in an enclosed container, to relax badly distorted, possibly gelatinized, parchment (1983, p.32). To remoisten dried out skins and make them more flexible prior to retensioning, parchment sheets can be gently rubbed all over with cotton wool dampened with alcohol (containing some water, not absolute alcohol). Take great care not to dislodge ink particles. Do not use on illuminated leaves. Slow treatment should never be carried out using a solvent containing water because of the greater danger of bringing about (further) gelatinization (Giuffrida, 1983, p.31-32).

   Cains, p.51, describes immersion technique of vellum leaf in methanol followed by insertion in polyethylene envelope (to inhibit evaporation of the methanol and contact with this toxic solvent) followed by manipulation to ease out distortion. He uses ethanol or isopropanol and water for local dampening of horny, relatively impermeable areas of skin.

2. Ethanol: Immersion of distorted, fire-damaged parchment rolls in a water/alcohol solution of 60% ethanol for 24-48 hours permitted unrolling. This was followed by tensioning and repeated brushing with the water/alcohol solution over 3 - 4 days so the parchment never dried out. When this treatment was followed by swabbing with or immersion in PEG200 the result was more "perfectly flat and obviously more soft than similar parchments not treated with PEG" (Tanasi 1984, pp.23-26).

   Dreibholtz (1991) describes use of alcohol and water mixture (4:1) on shrunken creased Middle Eastern parchments: spray hair side first to postpone curling of edges, place between wax or silicon paper and weight edges with small weights. Repeat this process as necessary. After final spray, put parchment into press under very light weight. After one day, replace the silicon with blotting paper. The object is pressed for 4 weeks or longer.

G. Other Lubricants

1. Lanolin Emulsion: 1% anhydrous lanolin in ethanol and water to lubricate fibers (for preparation and use see O'Hoski 1976, pp.69, 76).

2. Milk: Because the original "softness" of parchment was due to its content of natural grease, the addition of small amounts of acid-free fatty substances, such as milk, were thought to be helpful. Rubbed into the parchment, milk has been reported "to clean it and make it a little greasy". An associated risk was the potential generation of lactic acid (Wächter 1962, p.24).

18.4.9 Local Treatment

There are many occasions where one might consider performing more local treatment on a parchment artifact, either prior to or in lieu of overall humidification and flattening.

A. Treatment of Folds, Creases, Pleats

One of the most direct ways to locally humidify a fold, crease or pleat is to apply a solution of either 50/50 water/ethanol or pure ethanol or isopropanol along the crease or fold line. However it is possible that tidelines may develop in discolored skins. In addition, some surface preparations (especially highly napped parchments) and coatings may be disturbed by the direct application of water or solvents. In these cases one can try more indirect methods of local humidification such as small squares of polyester web, Gore-Tex and damp blotter over the area to be relaxed and flattened. An ultrasonic humidifier with a hose attachment can also be useful for local humidification of a small area. The "Preservation Pencil," sold by University Products, comes equipped with a plastic nozzle that fits on the end of the hose. For an even finer jet of ultrasonic mist one can attach a glass eye dropper or pipet to the end of the hose with some modifications. One must be extremely careful when using an ultrasonic humidifier in this way, however, because condensation will gradually build up at the end of the nozzle and drops of water may ultimately fall on the object. In order to prevent this from happening place the humidifier on the floor so that the condensation is able to drain back into the tank. On a regular basis, vigorously shake the nozzle off to the side of the work area, in order to expel any water droplets that have collected at the tip. One can also touch the end of the nozzle to a blotter every so often to wick up any free water that might have collected at the tip.

The local treatment of pleats in a parchment artifact may not always be advisable, depending on how the pleats have formed in the skin. If they are obviously the result of some type of mechanical damage or manipulation of the object (Clarkson 1992, Figs. 54a & 54b), they can usually be locally humidified and flattened out with a certain amount of success. If, however, the pleats have formed as a result of the expansion and contraction of certain areas of the skin, with changes in the surrounding environment, they may be much more difficult to remove. These types of pleats, which are seen more frequently in full thickness (i.e. unsplit) parchments than in modern split skins, are often associated with a type of cockling that is oriented parallel to the spine direction of the animal (Clarkson, 1992, Figs. 11, 25, & 26). When these pleats are located in the blank margins of an artifact, and do not extend into heavily painted areas, they can sometimes be locally humidified and dried under tension by an experienced conservator (Lee 1992, p.48). However, the manipulation of pleats in illuminated or heavily gilt areas could easily disturb the paint or gold nearby, so it is usually best not to attempt any form of local treatment in these situations (Lee 1992, p.47 and Figs. 4 & 6).

B. Treatment of Wide Splits/Tears

Splits and tears in a parchment artifact may begin to close up once the skin is humidified overall. However, as the parchment contracts upon drying these areas of damage will open out again and may even tear further, depending on the drying

method that is employed. For these reasons it is advisable to repair any splits and tears, in either a temporary or permanent way, before overall humidification and flattening of the artifact is carried out. If the split or tear is already well aligned, and requires no further manipulation, it is usually preferable to attach a permanent mend of transparent membrane, new parchment or paper to secure the area (see Section 18.4.11, Mending and Filling for a more complete description of these methods). If, on the other hand, there is a wide gap in the split or tear or if the area is misaligned due to distortions in the skin, a temporary repair might be more suitable at this point. Depending upon the area in the skin where the damage has occurred, and the proximity of sensitive media, tears can sometimes be partially closed or realigned with the local introduction of moisture (see techniques described above) followed by hand manipulation and drying under light pressure. Before the area is very dry, however, the temporary repair is applied. This can consist of a piece of Japanese tissue applied with starch paste or an adhesive-coated tissue such as heat-set tissue which is activated with solvent. Pressure-sensitive tapes have been used by some conservators for the temporary repair of splits and tears (Cains 1982/83, p.17) yet there is always the risk ofleaving some adhesive residue behind, especially if the skin has a prominent nap. For temporary repairs it is important to choose a relatively lightweight material which is very flexible and also easily removed at a later point. Therefore mends adhered with either gelatin or parchment size are usually not appropriate for this purpose.

At the Walters Art Gallery splits and tears in a badly mold-damaged parchment manuscript were recently humidified and temporarily repaired with the help of a book suction unit (described in Quandt 1992, pp.188-189). The first leaf of the manuscript was severely perforated and torn and many damaged areas were misaligned. The leaf was positioned on the suction table and then humidified overall under polyester web, Gore-Tex and damp blotters. Once the skin was sufficiently relaxed tears and splits were gradually realigned while the leaf was held in place under slight vaccuum pressure. Small pieces of a lightweight Japanese tissue, previously coated with a viscous solution of Klucel-J in ethanol, were positioned over the tears, moistened with ethanol, and pressed in place. Each patch of repair tissue was locally weighted, under squares of blotter and Plexiglas, as the work progressed across the leaf. Some tears and splits, which could not be completely closed or realigned during the initial stages of treatment, were rehumidified locally using Gore-Tex and damp blotters. The existing repairs were removed, the damaged areas were manipulated further and new temporary repairs were then applied. After all of the necessary work on the suction table had been completed the manuscript was removed and left under pressure for a couple of weeks, to allow the moisture content of the parchment to come to equilibrium. Temporary repair patches were gradually removed and the damaged areas were mended for a final time, using carefully profiled pieces of the same adhesive-coated tissue. (AQ)

C. Treatment of Horny or Shrunken Areas

Parchment artifacts that have been damaged by water or heat are often horny and shrunken in certain areas - usually around the edges that were most exposed. (These areas often have a translucent appearance as well, especially when the damage has been caused by water.) If this type of object is humidified overall the

rate of water absorption and the resulting relaxation of the skin can be very uneven, with the undamaged areas taking up moisture more rapidly than the horny, shrunken areas. This can lead to several problems, especially if the conservator prolongs the humidification process in order to relax and flatten out the damaged areas of the skin. In these situations it is sometimes better to treat horny or shrunken areas locally, either prior to or instead of overall humidification and flattening. Moisture can be introduced locally, using some of the methods described above, and the area can then be gently manipulated with the fingers and dried under pressure using small squares of polyester web, blotters or felts, Plexiglas and weights. If moisture alone is insufficient in relaxing the damaged area one can locally apply ethanol or isopropanol, either alone or in combination with water, by brush or spray or with a dampened blotter pack. Although methanol has been successfully used in the past as a softening agent for parchment it is extremely toxic and therefore no longer recommended. Other lubricants, such as urea and polyethelyene glycol (PEG), have been found to alter the character of parchment in a variety of ways and are also not recommended for current use (see Sections 18.3.2 and 18.4.8 for further information on Lubricants and Lubrication.)

18.4.10 Flattening/Tensioning/Drying

Many factors determine the choice of technique for drying a humidified parchment artifact, including (but not limited to) the weakness of deteriorated or mold-damaged skin, the presence of tears or losses, soft or fragile media, the presence of seals and other attachments, the quantity of material being treated, and the techniques at which the conservator is practiced. Every technique of drying is more successful when sensitivity and experience are employed in carrying it out, and when the procedure is carefully monitored so that the conservator can respond quickly, and possibly alter the process, if a problem arises.

A. Drying and Flattening under Pressure

Flattening under pressure is a commonly used technique for parchment. Some practitioners are opposed in principle to the use of this approach, because they feel it is important to always dry the parchment under tension, similar to the way in which it was manufactured. The idea is that since the initial drying of the wet pelt under tension first created the parallel alignment of the fiber bundles to which parchment owes its identity, this manner of drying must be employed in conservation practice in order to avoid altering the character of the skin. Others respond that keeping a humidified parchment immobilized under uniform moderate pressure during drying is equivalent to tension drying, and that this can be done in a sensitive manner so that no significant alteration of skin character can be observed.

There are several situations in which pressing is safer than tensioning, such as when a parchment is weakened by mold or other factors, and when there are tears within the sheet which may widen or lengthen under tension (see 18.4.9 Lubricants). A parchment that is very limp when humidified is vulnerable to distortion if it is placed under too much tension, and even the slightest distortion can be especially disturbing in a manuscript written in parallel lines or a print with a rectangular border, for example. Of course, existing distortions in a misshapen artifact will not be improved and may be exaggerated by flattening under pressure,

unless the pressing is combined with or preceded by tensioning (see 18.4.10.D). Pressing is usually the best option when media extend to the edges of an artifact and would be harmed by clamps, as in the case of trimmed manuscript leaves or fragments. Pressing can be advantageous when a large number of parchment objects must be flattened, since they can be humidified in quantity and stacked under pressure (with interleaving) quickly and with little space or equipment.

Sometimes it may not be possible to determine whether a parchment can or should be dried under pressure until the item has been fully humidified. Only then may it be possible to determine whether a previously deformed parchment lies flat enough when it is relaxed by humidification to be pressed without danger of creasing. Also, when a parchment is humidified its advanced state of deterioration may become apparent if areas look very wet, gelatinous, or translucent. This will of course happen if an artifact is over-humidified, and since mold-damaged skins are locally deteriorated, just enough humidification for some areas will cause over-humidification in others. In these cases the amount of pressure must be especially moderate, or permanent alterations may occur (see 18.2.5).

1. Pressing Between Blotters: When pressing a parchment between blotters under a weight, it is not advisable to humidify the parchment beyond the point where it is relaxed enough to lie flat. Excessively humidified parchment is more vulnerable to the hazards of excessive moisture when combined with excessive pressure (see 18.2.5). A rectangular piece of plate glass (taped at the edges to avoid injury to the conservator), or thick Plexiglas or pressing boards can be used for pressing (see 18.3.4 Tools and Equipment). If needed additional weight can be placed on top. The weight should be sufficient to discourage cockling of the blotters between blotter changes. The artifact should be placed between clean smooth pieces of polyester web such as Hollytex (see 18.3.5) to prevent bonding of the parchment to the blotter, to prevent offsetting of media and to avoid imparting the blotter texture to the surface of the parchment. As an added precaution smooth blotting paper with minimal texture should be used. Shortly after pressing begins (after a minute or less) the parchment should be quickly inspected to make sure there is no creasing or other problem. (A kitchen timer is useful for monitoring the first checks and blotter changes.) At this stage, if there is a problem, the parchment can be returned to the humidity chamber and there is a good chance the artifact will not have been pressed long enough to permanently mark it. If there are no problems, the blotters should be changed. It is important to change the blotters at brief intervals at first so that their cockling will not hamper flattening of the parchment. Blotters should be changed quickly so that the still partially humidified parchment will not begin to dry without restraint, thereby reintroducing cockling, shrinkage, or other deformation. When the blotters are no longer cockled by exposure to the parchment under weight, the item should be left under weight for a week or preferably much longer. The first 2-4 days the blotters should be changed daily.

   No matter how long a parchment is left under weight, it is not likely to remain completely flat for long once it is removed from the press. The skin will most likely reassume a natural undulation, especially when exposed to

humidity fluctuations (see 18.2.4). This must be accounted for in housing and storage of the artifact (see 18.4.13 Housing). It is helpful to make sure that humidity levels are appropriate in the workshop before removing the parchment from the press.

2. Pressing Between Felts: Thick wool felts (see 18.3.5) are often helpful for flattening because they can keep an item under pressure while providing a thick interlayer with more cushioning than blotters. They allow moisture to pass through, promoting slow even drying. They do not cockle like blotters when they are damp, and therefore do not have to be changed at intervals. When more weight is desired the felt can be doubled or tripled. The felt pile should be covered with a pressing board, and depending on the parchment, some additional light weight. Wool felts are light and impressionable enough to protect vulnerable media from crushing or flattening, especially illuminated leaves with raised gold leaf. A mold-damaged document can be safely pressed under felts in situations when flattening under glass or in a press would be out of the question.
3. Alternative Weighting Systems: Parchment is sometimes flattened in a variety of presses, such as standing or nipping presses. These presses are capable of extremely high pressures that are potentially very dangerous to parchment. However, when used with experience and sensitivity, they can be a useful tool, capable of precise amounts of pressure. The humidified object is sandwiched between polyester web, felts or blotter, and pressing boards. The sandwich is centered in the press and the flywheel is turned until the point that only platen pressure is exerted. It is unwise to increase the pressure beyond this point. Only moderate pressure is needed for flattening parchment. Remember to check the parchment after a minute or so to make certain that there are no creases or folded-under edges. (In working situations where equipment is shared by several conservators, it is advisable to leave a visual reminder, such as a sign, that the press is in use. This prevents the possibility of critical settings being unintentionally altered.)
4. Accommodation of Platemarks and Attachments: A frequent complication in pressing parchment artifacts is the presence of seals, ties, ribbons, and other attachments. Platemarks and embossings can be vulnerable to pressing, and the folded-over borders seen in many legal documents must be accommodated. Many of these accommodations are made in ways familiar to the paper conservator. Cut-outs can be made in the blotters used for pressing to allow for the extra thickness of attachments on the surface. As many blotters as necessary must be cut to accommodate the thickness of the attachment, with one uncut blotter placed on top. It is much more convenient to prepare these blotters before beginning humidification. Additional blotters for successive blotter changes should also be prepared in advance. Sometimes more than one attachment will have to be accommodated on a single document. Before humidification a parchment that is not horny can usually be spread out manually to find where these multiple attachments will be relative to each other after the sheet has been flattened, and a template can be drawn showing these locations. This template can then be used for making cut-outs in the blotters. For edges that

are folded over creating a double thickness, a single blotter on top of the document and butted against the fold-over edge may accommodate the difference in thickness. As with prints on paper, an extra blotter cut to the shape of the plate can be placed inside the platemark.In all these cases interleaving is placed between the blotter and the skin to protect the surface and media. It is also a good idea to insert spun-bonded polyester under fold-overs and beneath loose flaps of surface attachments to avoid cementing parts together during pressing which were not meant not to be adhered.

Pendant seals and ribbons can often be allowed to protrude from the press during drying. Most parchment bands and other types of attachments for heavy seals are thick and non-responsive enough to be allowed to dry unrestrained. It is a good idea to provide support for these attachments when they protrude outside the drying pack. It is generally not recommended to take apart, unlace, unfold, or detach attachments from documents for the sake of flattening. Some part or parts of the attachment may be too fragile to survive disassembly, and after the changes undergone by parchment in humidification and flattening, it may be impossible to put things back exactly as they were after the object has dried.

Approaches to flattening under pressure can be modified or combined to suit each individual problem, such as placing thick felts in a press when an object needs increased restraint but its surface or media need extra protection. Flattening under pressure can also be combined with tensioning techniques. This is routinely done in workshops where documents are tensioned until they are nearly dry, and then placed under pressure for the final stage of drying (see below).

5. Accommodation of Joined / Multiple Sheets: Multiple sheets are often legal documents which were joined using official seals or a lacing system designed to prevent tampering. Many of these systems can not be undone without doing permanent damage to these auxiliary materials or to the area of overlap with the sheets. Where the sheets are joined with cords, threads, or ribbons the condition of these materials must also be considered. Naturally if the sheets can be separated for humidification and flattening this treatment will be easier and more successful, but in most cases this is not possible. Thus, it may be preferable to settle for a document that, although not completely flat, still maintains its original configuration. If a multiple-sheet document if pressed as a unit, the amount of humidification and pressure it is exposed to should be very moderate, and a thin non-stick material such as smooth spun-bonded polyester should be inserted between all sheets to prevent their sticking together.

   Sometimes the top sheet of a multiple-sheet document may be more cockled than the successive sheets, and the treatment goal may be to increase the flatness of just that sheet. In that case the sheet can be humidified while remaining attached using Gore-Tex and blotters or any other system for local humidification (see 18.4.7 Humidification and 18.4.9 Local Treatment) and isolating it from the sheets underneath using polyester film. Similar techniques have been used for parchment book pages that remain in the

binding. The document can then be weighted under felts, or the single sheet can be dried under tension (see below). It is also possible, with careful planning and dexterity, to tension all of the multiple sheets at once (see Burns and Bignell 1994).

6. Hazards: The hazards particular to flattening under pressure should be emphasized. These include the translucency caused by gelatinization due to a combination of excessive moisture with excessive pressure, and the permanent pressing in of wrinkles and creases caused by pressing a parchment which is very distorted following humidification. Some parchments, usually very thin ones, have a marked tendency to curl when they are humidified, and if they are accidentally pressed with an edge curled in this may leave a permanent crease or possibly cause the edge to cement onto itself. There is also, of course, the risk of offsetting, or flattening softened paint or raised gold. This risk may become apparent only after humidification, at which time the conservator may decide to dry the object under tension rather than under pressure. Some conservators set up for both types of flattening before beginning humidification, so that they will be ready to proceed either way once they observe how a parchment responds to humidification. Further hazards are the crushing or bonding of seals or attachments, and the loss of relief of printing ink and platemarks.

B. Tensioning at the Edges

1. Tensioning by Weighting the Edges: This technique is less frequently used than tensioning with bulldog clips (see below), and does not lend itself as well to local adjustment/manipulation of the sheet as the latter technique, but it works well for artifacts with straight, regular edges. It may be especially practical for oversized sheets which are too large to place on a stretching board, and composite oversized sheets (larger sheets composed of smaller sheets which are attached to each other end-to-end) where the separate sections can be humidified with Gore-Tex and weighted at the edges and dried one at a time.

   Working through a protective barrier sheet such as spun bonded polyester the humidified piece or section can be pulled flat or smoothed by hand. Strips of spun-bonded polyester are laid over the edges, followed by blotter strips, then flat metal rulers or Plexiglas strips, and finally as many small weights as are felt to be necessary to provide the appropriate amount of pressure at the edges. Choosing the correct amount of weight is perhaps the most critical aspect of this procedure: too little weight will allow the parchment to slip from underneath as it contracts and dry unrestrained, and too much weight can cause marking, transparency, or damage to media at the edges.

   Refer also to Barbara Giuffrida's description of hand manipulation and local weighting (pp.35-36) as there is a difference of opinion in such working practices.

2. Tensioning with Clips and Pins on a Board: For maximum control during the drying process one should set up for tensioning before humidification begins. This way tensioning can be carried out at precisely the stage of humidification which the conservator thinks is optimal. A soft insulation board such as Homosote, or a thick block of Ethafoam, will allow for a

certain amount of movement in the pins as the skin begins to contract and dry under tension. Cloth-covered plywood can also be used for pinning out parchment yet, due to its greater rigidity, the pins tend to stay in one place once they are positioned. In order to introduce a greater amount of flexibility into the system it is common to attach rubber bands to the handle of each bulldog clip and hook the ends around the pins that are stuck into the board.

The type of pins that one uses for this method of tension drying can also affect the success of the process. The length and thinness of dissecting pins make them more prone to bending, once the skin begins to dry. This can make it more difficult to maintain an even tension around the perimeter of the object. In order to avoid this problem the length of the needle in commercial dissecting pins can be cut down to a smaller size so there is less material to bend.(NB) Alternatively, the pins can be made by hand using number 15 bookbinders sewing needles and short lengths of 1/2" thick wooden dowel. (For further description see Cains, 1982/83, p.21.)

The modified bulldog clips should be laid out on the board roughly in the shape of the artifact. They should all be laid with the same side down so that they will all pull at the edge of the parchment at the same angle. If using plywood as a tensioning surface loop rubber bands through the hole in the handle of each Bulldog clip. Position the pins in an accessible way so they will be easy to obtain when you need them. When the humidified artifact is laid on the board it is essential to work quickly so that it can be effectively tensioned before it starts to dry out. To this end it may be preferable to work with a colleague at opposite sides of the board, especially if the tensioning is tricky due to tears or an irregular shape, or if the item is over-sized. In such a situation some conservators are accustomed to replenishing the moisture in the artifact at intervals while they work, using an ultrasonic humidifier with a hose/nozzle attachment or a dahlia sprayer filled with a water/alcohol solution. One must be careful, however, not to apply moisture directly to an object that has sensitive media or surface preparations. For these objects is it better to raise the overall humidity in the room in order to prevent too rapid drying of the parchment and to permit a longer working time. In any case, tensioning should not be undertaken when the relative humidity is less than 50%, to avoid placing undue stress on the object as it dries out.

The clips are first attached to all sides of the sheet starting at the corners. It is important to keep the jaws of the clips level with each other along each edge to avoid creating clip marks. An unclipped gap will be left over at the end of each side. A small gap will permit easy repositioning of the clips later on (for reducing clip marks); if the gap seems large enough to interfere with even tensioning then the other clips on that side can be slightly spaced to fill in the end. Ideally no gaps are left between the clips in order to avoid uneven tensioning. When using plywood the clips are tensioned by stretching out the attached rubber bands with moderate tension and then inserting dissecting needles through the loop. In the other system employing a soft board the pins are placed directly through the lower hole in the clip handles. The needles are positioned at an angle, away from the

center of the board, so that they will hold the clip firmly and not be pulled out as the parchment starts to contract.

Most conservators work from the centers out toward the corners, placing pairs of clips opposite each other in order to keep the tension as even as possible. The amount of stress created between each pair of clips can be judged both visually and by feeling the tension of the rubber bands or the clips with the fingers. It is more important to get the entire sheet pinned out quickly than to lose drying time comparing each pair of clips as they are secured. After the sheet is pinned out one can inspect the entire sheet and again test the tautness of each rubber band or clip, making adjustments as necessary. If there are straight lines of printing or writing or straight drawn or printed borders a straight edge can be used to help with the visual evaluation.

Sometimes local deformations in a sheet can be improved by placing them under slightly more tension during pinning out. This can be risky, however, and should only be attempted by someone who is experience in the practice of clipping and pinning a piece of parchment. The whole tensioning process requires careful attentiveness, since the final shape and conformation of the artifact is being determined by the manipulations of the conservator. Parchment should not be over-tensioned to the point that it is drum-tight during this process. Although the sheet will usually not appear completely flat after it has been correctly pinned out, it will gradually become flatter as it contracts during drying. The moisture content of the skin can be checked during drying by gently touching its surface with the back of the fingers. The coolness of the parchment gradually decreases as it dries. If distortions should appear or existing distortions should worsen, the pins can be adjusted once more, or the parchment can be unclipped and returned to the humidity chamber while the conservator's treatment plan is reconsidered. If no problems arise, after a brief interval (5 minutes or so) all the clips can be moved a slight distance along the edge of the sheet in order to reduce the danger of leaving permanent clamp marks in the edges. The clips should not be moved more than once to avoid disturbing the drying process.

When the object is nearly dry (10 minutes-1 hour, depending on the thickness of the artifact and environmental conditions in the laboratory- the skin should be taut against the clips but still slightly cool to the touch) it is usually unclipped quickly from the board and placed under weighted felts or blotters for final drying. It should be left weighted for at least a week or preferably longer. This drying stage under overall pressure serves to reduce clip marks and any other deformations created by the clipping-out process. Sometimes a sheet will be placed under weight after a very brief pinning out, just long enough to eliminate the danger of creasing or wrinkling which might have occurred if the humidified parchment had been placed immediately under pressure for flattening. In rare cases a parchment may be so permanently and severely deformed that it can only be partially flattened using local treatment combined with tensioning. Even these distorted objects can, after tension drying, be padded with pieces of felt or other soft material such as polyester batting or surgical cotton for placement under felts and light weights.

3. Tensioning with Clips and Hanging Weights: In this system bulldog clips are attached to the edges of the artifact and tension is provided by small hanging weights that are suspended by strings from the "handles" of the clips. The principle of this method is that the humidified skin is held under light tension by the hanging weights. As the skin dries and contracts the clips remain firmly attached to the edges while the weights are free to move in response to the drying parchment. One of the difficulties, however, is in achieving equal tension around the perimeter of the artifact. (Giuffrida, p.34) Douglas Cockerell's technique was to support the object using a free-standing wooden frame on which strings are tensioned in either direction, making a grid-like pattern. (Cockerell, 1938, p.84 and Fig. 23) Once the parchment was humidified the clips were attached to the edges of the object and the small lead fishing weights were suspended from the clips by strings, over the edges of the stretching frame. Otto Wächter (1982, p.168) describes the use of a board to support the object during the tensioning process. The board is somewhat larger than the object all around and must be set up in such a way that the weights can hang freely from the clips, around all four edges of the parchment.
4. Tensioning on a Rigid Frame: This technique is derived from the method used in the manufacture of parchment, whereby the damp skin is tensioned on a rigid frame to dry. Giuffrida (pp.33-34) describes an Italian method that utilizes a circular hoop fitted with stainless steel clips and violin pegs. The clips are attached to the edges of the artifact while the violin pegs, which are connected to the clips by lengths of cord, are secured at 5 mm intervals around the circular frame. Adjustment of the tension on the skin is done with the violin pegs. Otto Wächter later perfected this technique by replacing the cord with chains, which could easily be adjusted in length according to the size of the object being tensioned. (Wächter, 1982, pp. 167-168) One of the main advantages of this system is that, because the frames can be positioned vertically, it is possible to view the object from both sides during the drying process. (Giuffrida, p.34) A more recent modification of this technique was developed by Smith and Bunting (see Special Considerations 18.6.6). They use a stretching frame similar to that designed by Cockerell (see above) which consists of a wooden strainer with fishing line tensioned across in a grid pattern. In this case, however, the nails that hold the nylon line around the perimeter of the frame also act as rigid points against which the skin is tensioned. Rubber bands, instead of lengths of cord or chain, allow for more flexibility in the attachment of the bulldog clips to the object.
5. Accommodation of Attachments: Many attachments do not interfere with or influence the tensioning/drying process. Some seals, however, which are attached to the surface with water-sensitive adhesives could pop off during drying and would have to be reattached after the artifact is dry. Pendant seals that are laced in close to the edge may interfere with the placement of clips. When objects with unusual shapes or irregular edges are tensioned the process is still the same for the most part, although not all the clamps will extend at right angles from the edges of the artifact. By observing the

surface of the item during pinning out it should become apparent which arrangement of clips will achieve the most level surface possible.

6. Accommodation of Joined Multiple Sheets: Although the technique requires a certain amount of skill and confidence it is possible to dry and flatten joined parchment sheets using a tensioning method. (See Burns and Bignell, 1993.)
7. Hazards: Tensioning of parchment is not without its hazards. Improper tensioning can cause distortion of the plane or the shape of an artifact. Excessive tensioning, especially in combination with excessive humidification, can permanently increase the dimensions of an object (overall), cause tears in weak areas, or enlarge existing tears if they are not adequately secured beforehand. The clips can damage softened media. In addition, the following problems can occur when using some of the tension-drying methods described above.
    a. Splits, Tears and Weak Areas: Tensioning is riskier, or at least more complicated, when a sheet is weak or torn. These areas should be watched closely to avoid over-tensioning during the pinning out and drying process (See 18.4.9.B Tensioning at the Edge). Weak or torn areas should be mended or reinforced before humidification and flattening. The mends which are applied can be temporary, to be removed immediately after tensioning is completed, or permanent, if applied to areas which will ultimately need reinforcement. If the mends are meant to be temporary, they do not need to be aesthetically appropriate. They need only be strong enough to withstand the stress they will be placed under during tensioning. If they are temporary, the mends should be removed before placing the parchment under pressure, after tension drying is completed.
    b. Transparency Caused by Excessive Moisture and Tension: Depending on the degree of moisture in the skin, and the type of weights used in this method of tensioning, it is possible to create transparent areas in the skin. In order to avoid this problem it is important not to overly humidify the skin and to use relatively light weights for the tensioning process.
    c. Clip Marks and Distortions: There is always the danger of leaving clip marks and distortions at the edges yet they can usually be dealt with in the following ways. The modification of the bulldog clips can be improved by adding more cushioning and by making sure that the jaws of each clip are parallel to each other (see 18.2.4.A.1). The clips should be repositioned during drying (see above). Distortions and scalloping at the edges can be alleviated by making sure that the jaws of the clips are level with each other along each edge, and by not leaving gaps between clips. Isopropyl alcohol or alcohol/water can be applied locally to the marks during repositioning and/or prior to weighting. Also, a final local humidification and flattening can remove clip marks.

C. Stretch Drying on Terylene

This method of drying was originally developed in Europe and is currently used in many large libraries and record offices in the U.K. A large sheet of Plexiglas is

roughened slightly so as to adhere better to the terylene. A piece of terylene cloth with a smooth surface is then pasted to the Plexiglas and an additional coating of paste is applied on top of the fabric. The parchment artifact is humidified and then smoothed out on to the terylene, while the paste is still moist. Although flour paste is typically used for this step it often leaves a rough greyish film on the parchment surface. In order to avoid this unpleasant residue parchment size has been recommended as a substitute. (Giuffrida, p.36)

D. Vacuum Suction Table Flattening

1. With Gore-Tex Over Object: Flattening parchment on a vacuum suction table can often be the best method available to the conservator. It provides even support under the piece at all times critical when handling fragile, damaged parchment. It can be easier to obtain successful results with none of the caveats of the traditional tension or pressure drying methods, such as planar distortions, clip marks and increased tearing of fragile and weak artifacts.

   The parchment is humidified overall using whatever method that is appropriate for the object. Since the suction table is part of this treatment, humidification using a dome and ultrasonic humidifier on the suction table (with the suction turned off) can be a convenient option. If only one piece of parchment is in need of flattening it can be humidified directly in place on the suction table. Otherwise a humidity pack set up near the suction table can facillitate the treatment. (See 18.4.7 Humidification.)

   The suction table is prepared with a thick piece of blotter covered with a piece of polyester web. To close off the airflow the perimeter of the suction table is covered with a silicone rubber membrane or polyester film. Once the skin is relaxed, the parchment is laid on the blotter. Turning the suction table on a low setting the skin is carefully manipulated, usually from the center outward, to pull creases and distortions into plane and to close splits and tears. (Low suction will provide more working time and is appropriate for medium to thin skins; higher suction may be necessary for thicker skins.) Parts of the parchment can be protected from the suction until the conservator is ready to deal with them by placing a piece of Mylar under the area. A plastic ruler can be used as a guide to ensure lines of text are straight. As the skin is manipulated into plane, the edges are covered with strips of Mylar to hold them down and prevent curling. The working time, rate and eveness of drying can be adjusted by working inside a plexiglas or polyethylene hood with an ultrasonic humidifier to provide the desired level of overall humidity. Certain areas of the parchment can be covered with polyester film to retard drying, especially when there are joins or areas of the skin that vary significantly in thickness. A hose attached to an ultrasonic humidifier can be used to provide moisture locally as necessary.

   As the flattening progresses one turns up the suction until it is at its maximum setting. The drawing out of distortions usually only takes a minute or two, during which time the skin is beginning to dry. After the distortions have been worked out, the parchment is covered with a dry sheet of Gore-Tex (slick Teflon side in contact with the object), which provides an even overall restraint for the parchment as it gradually dries on the table. The Gore-Tex

material is an excellent filter and will inhibit any impurities in the air that might otherwise be pulled into the parchment surface. After five to ten minutes uncover the parchment and turn the skin over; it will have stabilized by this time but will not be fully dried. Recover with Gore-tex and continue to dry for another ten to twenty minutes. The skin by this time will probably still hold approximately 15% moisture which can be tested with a moisture meter. (The Digital Mini Protimeter, available from Museum Services Corporation, is very accurate, easy to use, portable and reasonably priced. The meter has interchangeable sensor surfaces, one of which is a soft foam head that is extremely appropriate for the delicate surfaces of parchment. (LP)(JFM)

The next step is to turn the suction table off and place the parchment between blotters and cover with weights. After several days recheck the moisture content; ordinary parchment with no coatings contains 10% moisture at 50% RH, while at 75% RH parchment can contain as much as 25% its weight in water. At the Folger Library single documents that have been flattened on the suction table are frequently encapsulated in polyester film at this time. There are several advantages to flattening on the suction table. This procedure is very useful in reducing creases and severe distortions that might tend to crease if the parchment were placed under pressure. The skin can be observed and adjusted until all the distortions have been returned to plane; at that point it is usually covered with Gore-Tex. When working on severely damaged artifacts it may not be possible to remove all distortions before the skin begins to dry. When this occurs the distortions are simply allowed to remain. Upon rehumidification the previously flattened areas will lay out flat, thus allowing the conservator to concentrate on the remaining distortions. This can be repeated several times until the practitioner is fully satisfied. This procedure is very helpful in closing and aligning tears in parchment. It is also useful for skins with sensitive media when the sensitive areas do not require direct manipulation. Gore-Tex has a very smooth surface that discourages offsetting.

Some conservators feel that, for media that has become softened during the humidification process, the momentary application of warm dry air can be used to prevent off-setting on to the polyester web or Gore-Tex. Under very specific and controlled circumstances the wafting of warm air (delivered by a hair dryer) can be used to reharden softened media. This is particularly important if the painting is on both sides of the object, but must be used with such care as to prevent any drying of the parchment's surface. With this method, however, the possibility exists that the softened binder (usually gum or glaire) will shrink and ultimately crack in reaction to localized drying with warm air from a hair dryer.

2. Hazards: The hazards are similar to those encountered in flattening distorted paper objects on the vacuum suction table. Distortions can collapse into creases if the initial suction is too great, manipulation can cause tears, stretching and additional damage to the support. Manipulation can also damage sensitive media. Softened media (especially thickly applied paint layers) can be offset onto adjacent interleaving and there is the danger of flattening raised gold leaf, especially if the gesso layer has been softened.

Water-damaged parchment documents with water damage that have gone translucent cannot be made more opaque as is sometimes possible with the traditional stretch drying methods.

Parchment should never be completely dried on the vacuum suction table. If the parchment is left to dry on the suction table on one side only, when it is removed it may have a tendency to curl and this situation can be difficult to rectify.

E. Combination Methods

1. Temporary Tensioning with Tape and Placing Under Weight: When the conservator wishes to press a parchment artifact but there is enough distortion after humidification which could cause creasing in the press, temporary tensioning with tape can be considered. This technique is more appropriate for archival material where parchment and media are not deteriorated and when flatness of the document will contribute to its safety in storage and use.

   A piece of spun-bonded polyester such as Hollytex is cut to the size and shape of the artifact. The polyester is placed on a blotter on a pressing board, and then the humidified item is placed face-down on the polyester. Working quickly, usually with a colleague working opposite, the artifact is tensioned by hand just enough to expand areas which may crease, and secured to the blotter underneath using masking tape. Masking tape is used because its thick paper carrier and relatively low-tack adhesive permit it to be quickly and easily removed from the parchment. (To speed up the process this tape should have been torn up into small pieces and attached to the edge of the work table ahead of time.) The masking tape is secured very lightly only to the extreme edge of the parchment and only on the verso. Depending on the nature of the deformation, tape may be needed along all edges or only adjacent to the areas of local distortion.

   The taped item should be covered with a clean sheet of spun-bonded polyester, blotters, and a board or glass plate for pressing. The pressure must be light as in all pressing procedures, but especially in this case to avoid bonding the tape permanently to the artifact. The item should be checked very shortly afterwards (1 minute or less) to make sure that creasing has in fact been avoided, and that the flattening is otherwise satisfactory. (If not, the artifact should be returned to the humidity chamber and the treatment reconsidered.) The top blotters can be changed at this time, and the item should be replaced very quickly under pressure. After another short interval (2-3 minutes) the item should again be uncovered and the tapes very quickly peeled off, permitting the the bottom blotters to be changed. At this time the ease of removal of the tape is crucial. If the artifact begins to dry before all the tape can be removed, it should be returned to the press and the remaining tapes removed during the next blotter change. If the tapes are left in place too long or pressed too hard, there is a danger that they could skin the parchment when they are removed.

2. Tensioning During the Process of Humidification: Although not widely practiced a combination method of humidification and tensioning has been used by some conservators. With this method the skin is first tensioned on a

frame using Bulldog clips and hanging weights. Moisture is then introduced into the skin using damp blotters, sandwiched on either side of the object, or by positioning the object over a tray which contains water or a saturated blotter. The humidity level is maintained by draping the object with a sheet of polyethylene.

3. Hazards: Tensioning with tape would not be suitable for artifacts that have media which extend to the edge of the verso; that have media which are liable to smear or offset after humidification; or that have a nappy or otherwise delicate surface that would be damaged by removal of the tape or the tape adhesive. It is also very likely that some of the tape adhesive residue will remain, (even though it may not be visible to the eye.)

F. Flattening/Tensioning in Incremental Stages between Humidifications

Sometimes a difficult flattening/tensioning problem can be solved by either repeating the same procedure after rehumidification of the object, gaining incremental improvement of the results with each repetition, or by using different approaches successively, such as local treatment followed by tensioning followed by pressing under weight. Barbara Giuffrida was able to flatten a badly damaged manuscript by easing out the skin with her hands and then placing small pieces of plexi and light weights on the outer perimeter of the sheet. The object was allowed to air dry under tension and it was then rehumidified and the tensioning process was repeated until most of the deformation had been removed from the skin.(NS) A similar process using gradual tensioning involves clipping and pinning out a humidified skin on a piece of soft board, yet one must be careful in the beginning not to put too much tension on very distorted areas. These distortions can often be worked out of the skin if it is dried under light tension and then humidified and tensioned again for a second or third time. In certain cases however, when the distortions are related to naturally loose areas in the skin (such as the axilla) rather than to damage by water or heat, it can be extremely difficult to achieve a flat planar appearance.

G. Emergency Drying (Disaster Salvage)

Water in an emergency situation can cause stains and dimensional changes that will permanently disfigure parchment. If a saturated skin is allowed to dry unrestrained it will develop horny and translucent areas that usually are impossible to reverse later on. Media softened by moisture is prone to smearing and off-setting. Elevated temperatures and high humidity also create an environment that encourages mold activity, with mold growth occuring within 24-48 hours in these situations. For these reasons parchment should be dried as soon as possible if it is wet.

Parchment artifacts that are wet or very damp are extremely susceptible to mechanical damage and must be handled carefully. When removing them from a disaster scene they should be transported using an auxiliary support. In an emergency situation parchment should, if possible, be identified and segregated from paper and other materials. Where large quanti-ties of parchment are affected a separate area should be set up for triage of parchment, because its emergency treatment may be quite different from that appropriate for other types of material. Books with vellum pages or covers should be included in this grouping. Framed

artifacts should be unframed as soon as possible, while remaining alert to the danger of adhesion of the skin or media to glazing. Some framed objects may be tensioned on strainers or drummed on to board. If allowed to air dry they are subject to severe warping and splitting as the skin contracts against the rigid support. Therefore controlled drying is especially important for these objects.

The immediate goal of emergency treatment is to stabilize the artifact before any further damage occurs. In some situations heavy deposits of wet mud can be lightly blotted off or removed mechanically, but there is a risk that the media, surface preparation, or skin below the mud could be damaged in the process. Usually it is safer to remove dirt after the parchment has been dried. Water-damaged media may also be best treated after the artifact has been dried. Freeze drying and vacuum drying usually cause some dessication of the binder, leaving the media loose and powdery and in need of consolidation. After the water-damaged parchment has been dried rehumidification and controlled drying and flattening will often improve the dimensional characteristics of the skin and return it to plane.

The chosen method of drying will usually be determined by the number of artifacts that have been water damaged in a disaster. In most situations a large volume of material will require immediate attention and methods of mass treatment such as freezing and freeze drying are preferable. If, however, only a single artifact or a very small number of artifacts have been water damaged the conservator may consider some of the more standard methods used for drying parchment. For example, small quantities of damp parchment documents that are not seriously deformed and with media that are not vulnerable can be dried and flattened under light pressure between polyester web interleaving and thick blotters or blankets. (See 18.4.10 Flattening/Tensioning/Drying) Parchment that is wet, however, must be pressed with extreme caution as its vulnerability to the hazards of excessive pressure are heightened. (See 18.2.5 Potential Alteration/Damage to Object in Treatment.) Also, pressure on parchment can cause a heavy accretion such as mud to embed itself in the surface. Uneven wetness may also be a problem, causing localized cockling or swelling, and complicating drying procedures. Wet areas may also crease or turn translucent under pressure. In one case a single waterlogged parchment document was successfully dried on the suction table (Logan and Young 1987.) Unfortunately, in an emergency situation the time or the facilities for suction table drying are often not available.

Tensioning is very dangerous for wet parchment because of its weakened state and must not be used. (See 18.2.5 Potential Alteration/Damage to Object in Treatment.) Tensioning would also be inappropriate for partially wet parchment, as stretching would concentrate in the wet areas, causing local distortions. If none of the usual drying techniques are feasible in an emergency situation, then the parchment artifacts should be frozen. Freezing "converts the water to ice, halts distortion in position and arrests (but does not kill) mould growth. Freezing buys time to think, to respond sensibly to problems and to make unhuried decisions." (Parker 1993, p.176.)

If time permits single parchment artifacts may be interleaved with freezer or waxed paper before they are placed in containers such as plastic milk crates to be frozen in groups. (The presence of holes in the crates allows for the passage of air during

freezing. Crates or boxes with solid walls can slow up the freezing process by insulating the material inside, so these should not be used.) The crates should not be overfilled or there may be too much weight on top of wet artifacts at the bottom. As in any emergency situation, the contents of the crates should be identified and kept track of as best as possible. Books with vellum covers or leaves can be wrapped tightly to help prevent distortions from developing during freezing and subsequent drying. Bagging books in polyethylene or interleaving them with plastic before they are put into crates will help in later retrieval of the material. In some situations, it may be appropriate to remove vellum covers before freezing to avoid distortion of the text block and permit separate treatment or replacement of the cover material.

In the case of books with parchment leaves and media that are water-sensitive, strapping the volumes may increase the extent of offsetting of the media. At the British Library recent tests with a variety of freezing and freeze drying methods have shown that illuminated parchment must be handled in a particular way to avoid further damage to the media. During initial salvage of water-damaged material books that are already flat should be removed from water horizontally. If, however, the books are still standing on a shelf they should be transferred to a crate in an upright position "so that water will not flow onto fresh pigment, but will only move slowly by absorption due to the hygroscopic nature of vellum." (Parker 1993, p.182.)

After freezing there are four possible ways to dry parchment. The first is to thaw the parchment at room temperature in a closed humidity chamber. This conditioning may include a period of exposure to air-drying which stops short of allowing the parchment to dry out, followed by returning it to a humidity chamber. The advantage to this approach is that skin which is too wet or unevenly wet can be moderately and evenly humidified, so that one of the customary drying techniques can be employed. It also permits monitoring of water-sensitive media during drying.

Freezer drying, vacuum freeze drying,and vacuum thermal drying are three additional ways frozen material can be dried. All these techniques can be expected to result in some shrinkage and embrittlement of the parchment, although the embrittlement reportedly recedes as the parchment acclimatizes to moderate environmental conditions. Shrinkage can usually be remedied with rehumidification and controlled drying of the artifact. For some archival material, however, the shrinkage may be considered unimportant. These three techniques do not improve distortions, and can cause further dessication of media and adhesives.

Freeze-drying occurs if frozen material is left in a self-defrosting blast freezer long enough. (See Ogden/Buchanan 1992, for a description of all three freeze-drying processes). This method requires temperatures below -10 degrees F. and may take up to several months. Vacuum thermal drying dries material under vacuum above 32 degrees F. and is likely to cause additional distortion of parchment during the drying process. This distortion can be especially marked in the case of complex artifacts such as books and scrolls. Vacuum freeze drying is carried out below 32 degrees F. and is not supposed to create any new swelling or distortion while it dries by sublimation of the ice content.

18.4.11 Mending and Filling

A. Considerations in Mending Parchment

1. Mending is not needed for flat parchment as often as for paper because tears or breaks in healthy skin are not as likely to increase by lengthening or branching during normal storage, handling, or flexing. Fragile modern split skins are the exception to this rule. On the other hand, if stretched, the parchment will expand and contract with the changes in relative humidity, putting a strain on an unsupported tear.
2. Often when a break occurs in parchment a gap widens more than one would expect in a paper sheet because of the parallel alignment of the collagen fibers in parchment. Reaction of the skin to temperature and humidity can increase this widening. It is usually necessary to accept a wider gap when a tear is mended because forcing the edges to meet will cause cockling throughout the sheet which can not be corrected. Even if this cockling seems to be corrected by flattening or tensioning, it will often return very shortly after treatment. (See 18.4.9.B Local Treatment of Wide Splits/Tears.
3. Parchment requires a stronger adhesive than paper does, because smooth healthy parchment provides a surface that is less easily bonded. The presence of grease in a skin will also affect the bonding of a repair. The bond must be strong enough to withstand the increased movement to which parchment is prone in response to humidity changes. However, a seriously mold-damaged or otherwise disintegrated parchment may have lost so much of its integrity that it may respond only weakly to humidity fluctuations, and a weaker adhesive will be adequate. In fact, a too-strong adhesive can introduce tension into a weak skin that can lead to tearing. Also, the surface may be so crumbly or powdery that a stronger adhesive may pull material from the surface of the parchment, creating a skinned area.
4. The moisture content of water-based adhesives should be carefully controlled because of the hydroscopic nature of parchment. (See 18.2.5.A. Problems Caused by the Use of Water or Excessive Moisture.) This may require using dryer, more viscous adhesives, and drying the mend under weight with stricter attention to the amount and duration of the weighting. Excessive weight on a wet mend could conceivably introduce the hazards associated with excessive pressure during flattening (see 18.2.5.B.) Inadequate weighting can lead to cockling of the skin and failure of the mend. A tacking iron must not be used to dry the adhesive of a mend because the heat of the iron will damage the parchment see 18.2.5.D.
5. Unlike paper, the thickness of an animal skin can vary considerably. These variations, which may be more evident in a large piece of parchment, may be from natural differences between areas of a skin (i.e. neck and butt being thicker than the belly or axilla) or from the manufacturing process, such as uneven scraping. Therefore the thickness of mending material, the strength of the adhesive and weighting of the mend may also need to be adjusted for repair of tears and losses in different locations within a sheet.

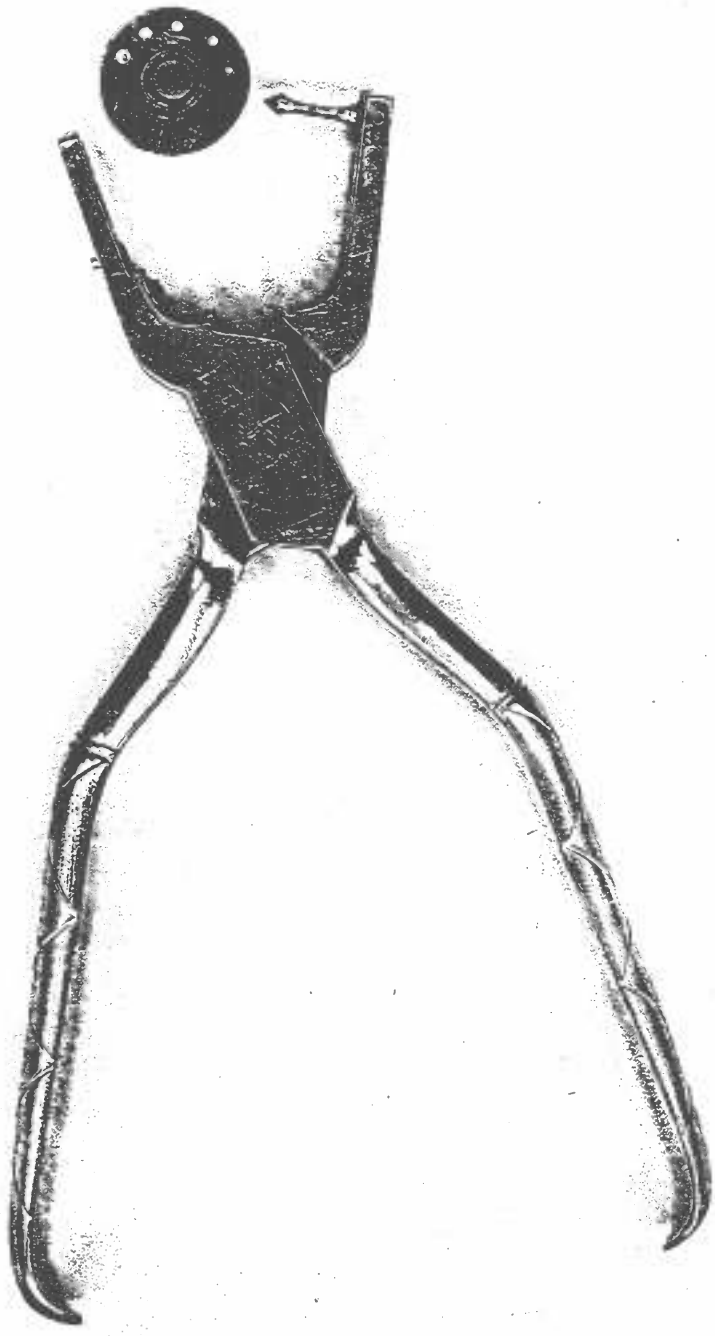
6. Due to the strength and reactive nature of parchment it is often necessary to mend both sides of a tear or split.
7. Knife cuts which originated in the manufacture or preparation of a parchment sheet should not require mending unless they are contributing to loss or damage. (See 18.2.2 Technological Features and Clarkson 1992).

B. Sewing

Repair by sewing derives from the original repair methods carried out by parchment makers on ruptures inherent in the skin or which arose during the course of manufacture. The need for this type of repair is generally due to a specific set of circumstances and occurs only occasionally. The most common reasons for sewing are to satisfy visual or physical requirements of the object. Sometimes it is necessary to resew original repairs when the thread is missing (although this is usually only needed when the rupture occurs at the outer edge of the sheet). Thread may also need to be replaced in oversized or rolled artifacts where the individual sheets were originally joined by sewing. Sewing is sometimes used for previously unsewn parchment manuscripts where a particularly strong join is desired, or where there are no overlaps along the repair, as in a knife cut. Sewing may be particularly appropriate for tears when the parchment must be stretched over a frame, such as in a work of art on parchment that is on an original strainer.

The traditional nature of sewn repairs is appealing to some conservators and curators. However, there are several problems with this technique when it is used for repairs other than replacing original sewing. It will only work where the area to be sewn is strong and healthy. (Some conservators have dealt with this problem by reinforcing the edges of the knife cut or tear with transparent membrane before sewing across the break.) A sewn repair might cause distortion or tearing if it hinders the natural movement of the parchment in response to humidity fluctuations. However, this problem has not yet been observed in situations where new sewn repairs have been executed on parchment artifacts. The method involves perforation of the object, which is generally objectionable in most types of conservation treatment. However, there is a difference of opinion among conservators of parchment on this particular point. While some individuals feel that the practice is unacceptable, due to the fact that new holes are being created in an original artifact, others are convinced that, in certain situations, sewing can be more suitable (and also more appealing to the eye) than other forms of patch repair using transparent membrane or new parchment.

Sewn repairs are most commonly carried out with either parchment strips and linen thread. Descriptions of the technique are given by Cains (1982/83) and Giuffrida (1983). Both these articles contain diagrams of the technique. The sewing material should be as fine in proportion as possible. The leading end is tapered and the thread is stiffened, using parchment size for parchment or PVA emulsion for thread. The sewing material is pulled and lightly tensioned through pre-perforated slits. The slits are created with a small chisel made by modifying a sewing needle. They should be staggered for a less bulky repair, and a figure-eight sewing pattern is used so that the edges will butt and not overlap, which would also make the repair bulky.



In a related technique round sewing holes are created using a dental tool (see photocopy). Some conservators prefer the physical integrity of a round perforation to a slit. The "baseball" stitch is an alternative sewing pattern and some conservators prefer sewing with sinew. (To prepare the material for use the sinew should be soaked in brine to remove blood followed by rinsing in fresh water to remove salt. Press the sinew out to dry on formica. See Reed 1972, p. 107 for further information on sinew production.) Create the "sewing thread" by fraying out the sinew and then strip off as much as is needed. Moisten the leading end with saliva to harden for sewing. At the completion of the sewing pattern the leading end has returned to the point of beginning. Secure the two sinew ends by overlapping, moisten and weight until dry. The sinew is self-adhering so there is no need for bulky knotting. (JT)

One advantage of sewing up tears is that one can place the holes vis-a-vis the text and thus avoid obscuring anything. It can be less obscuring than using overlays of fish skin or other thin skin.(NP)

Hazards: permanent alteration of the skin occurs when it is perforated for sewing. The raised surface of the thread or parchment lacing and knotting can imprint or abrade the surfaces of adjoining leaves. As the ends of slits are prone to splitting round holes are preferred by some conservators.

C. Transparent Membrane Repairs

1. Goldbeater's skin and Fish skin: Transparent membranes such as goldbeater's skin and fish skin are usually employed for the repair of small tears and perforated areas in a parchment artifact that do not require a great deal of support. Although a variety of adhesives can be used for attaching the membrane gelatin or parchment size are most common. Natural membranes are particularly useful for overlaying damages in text or image areas because they are so transparent. However, some conservators find that these materials are too shiny when applied to parchments that have a very pronounced nap. Goldbeater's skin or fish skin can also be very useful in supporting a large parchment fill, especially when the loss occurs in an area of text or image. (See 18.4.11.H Parchment and Transparent Membrane.)

   Since both goldbeater's skin and fish skin are very thin and reactive to aqueous adhesives the use of a temporary support can greatly facilitate the cutting out and attachment of the repair. Anthony Cains first introduced the technique of mounting transparent membrane to heat-set tissue as a temporary carrier. (See 18.3.3.B Animal Membrane.) In this process the heat-set tissue is adhered in advance to a large piece of membrane. The repair patch is cut out using scissors, a scalpel or an architect's swivel knife. Adhesive is applied to the membrane, which is then positioned over the area of damage and gently pressed in place. The heat-set tissue can be released immediately after the repair is secured by simple peeling, if the adhesive has not cooled too much during the repair process, or by applying organic solvent (usually ethanol or acetone) to the tissue with a brush.

   Several other techniques of temporarily supporting a mend of transparent membrane during the repair process are currently in use. One method

employs polyester web which is attached to the membrane with Tylose MH300 (a cellulose ether) in advance and then dried under pressure. The patch is cut out of the laminate, adhesive is applied to the goldbeater's skin and the patch is adhered skin side down. Once the repair has dried in place the lining of polyester web is removed using moisture.(UB) Another technique uses a piece of light weight polyester film as the temporary support. The goldbeater's skin is pasted out on the polyester film and excess paste is wiped away from around the edges of the membrane. Holding the edges of the Mylar support the goldbeater's skin is positioned over the damaged area and pressed in place. The Mylar is peeled away and the repair is dried under pressure with polyester web and blotter.(DE)

2. Sausage Casing: Sausage casing is currently used in many large libraries and record offices in the U.K. (See 18.3.3.C Reconstituted Collagen.) It is less expensive and more readily available than transparent animal membrane, and because it is made from a variety of materials including collagen, it does not react as strongly to moisture and is therefore easier to handle than the natural products. The use of sausage casing for the repair of parchment is described in detail by Giuffrida 1983, pp.30-31.

   Among many present day conservators of parchment there are several objections to the use of sausage casing for repair. The material usually has a distinct yellow tone that makes it more visually apparent than goldbeater's or fish skin. It has a relatively poor tensile strength when compared to the natural membranes; with some products the strength of the material seems to decrease upon aging and it gradually becomes very brittle. The variety of methods of manufacture (natural casings, reconstituted collagen casings, non-edible sausage casings, thermoplastic casings, etc.) make it important to know how the casing under consideration was manufactured. (See Karmas 1974, for further information on the manufacture of sausage casing.)

D. Parchment Repairs

A widely-accepted method of filling losses involves the use of new parchment . A loss is filled with material that is as similar as possible to the original so that the sheet and the fills will expand and contract uniformly in response to humidity fluctuations. Skin is chosen for the fill that is similar in thickness and appearance, from the same animal species, and if possible, conforming to the orientation and location of the skin on the original animal's body. There is certainly an aesthetic appeal to the preference for filling like materials with like. However, identifying the species of old parchment is sometimes extremely problematic. (Sometimes it can even be difficult to distinguish parchment from paper- see 18.2.1.B) Also, there are numerous factors that influence the physical behavior of parchment. These include the age and physical condition of the animal, biological variations and breed differences within the species, and injuries, scars, bruises and other anomalies in a particular skin. Country of origin, age and extent of deterioration of the parchment artifact, the history of its storage and use, and innumerable variables in the method of manufacture are further influences on the character of parchment. Contemporary parchment manufacturers have thus far been unable to replicate the quality of ancient parchments, and ancient parchments in general respond very differently than modern ones to humidity fluctuations. Maria Cristina Berardi's

1993 study of parchment deformation Why Does Parchment Deform? Some Observations and Considerations(see bibliography), concluded that the individuality of behavior of a particular parchment prevails over its species characteristics, and supported the use of Japanese paper as an alternative fill material.

Some practitioners advocate the use of a more generic parchment fill material which is dyed, trimmed, and thinned to suit each particular parchment artifact. Anthony Cains in his article Repair Treatments for Vellum Manuscripts (see bibliography) describes the preparation and use of fetal calf parchment (i.e. slunk) for infilling. According to Cains, the fill should be thinner and more flexible than the original. If necessary the skin is taped to a glass and placed over a light box for thinning with a very sharp spoke-shave blade, always from the flesh side. Any other surface preparation can then be carried out, such as sanding or pouncing. The material can be toned a sympathetic color with aniline dyes, either by surface application or by immersion. (See 18.3.3.A for further information on toning parchment for repair.) It is best to carry out toning before beveling so that when the fill is inlaid the overlap will not create a dark border. Bevelling ("scarfing") is done widely (3-5 mm.) so that the bonding surfaces are wide enough to ensure a firm attachment. Bevelling can be done using scalpels, knives, or flexible-shaft drills. Sanding sticks made by gluing fine sandpaper to wooden dowels can also be used. Generally only the infill is bevelled, never the original.

Some conservators do feel, however, that the original may be bevelled. Roger Powell always bevelled the original where possible. This was not done on Kells, though, because the custodians didn't want any original material removed (see Powell, 1956). Nicholas Pickwoad has often bevelled the original, believing it gives excellent visual results with great strength. This is only done where there is no text or decoration that would be removed or put at risk. Multiple repairs that lie over each other in bound books can give serious problems with swelling without such scarfing (more a problem when using parchment for repair than paper). (NP)

E. Japanese Paper Repairs

Japanese paper is used by some conservators for mending tears and filling losses in flat parchment artifacts. Although Japanese paper is a material that is foreign to parchment, with dissimilar behavior and appearance, it can function well. The paper conservator used to repairing with Japanese paper may choose to repair a tear in his/her customary way (see Paper Conservation Catalog Mending), but must take into consideration that a stronger and dryer adhesive is necessary in order to get the paper to stick. As mentioned above, a tacking iron should not be used for drying the repair. The paper should be thinner and weaker than the parchment, so there is little danger of it straining or deforming the skin over time. For weak, degraded, or thin parchment, a thin paper may be the best mending choice, because any new parchment or animal membrane is likely to be too strong. A repair that is too strong can also skin the surface of a degraded parchment.

For thicker paper to fill losses, as many layers as desired can be laminated together. For the sake of appearance the paper fill should be thick enough to approximate the opacity of the original; it is not necessary for any functional reason for the fill to be as thick as the original. If the fill paper is laminated alternately crossing the grain,

this and the presence of the adhesive will reduce the response of the infill to humidity fluctuations. It is true that such a non-responsive fill will not move in unison with the surrounding parchment, but if one accepts the difficulty of matching the movement of parchment fills to parchment artifacts (see Berardi 1993), one might settle for a fill which can at least be predicted not to move in conflict with the artifact.

Paper mends and fills can be toned a sympathetic color using watercolor or acrylic paints. (see 18.3.3 Mending Materials for further information on toning paper for repair.) In order to imitate the surface appearance of parchment paper surfaces can be burnished (before inlaying) with a bone folder. Very good imitations of the appearance of those parchments that have a hard, smooth surface can be achieved by loading the surface of the fill paper with starch paste or PVA dispersion, drying, and burnishing the surface. SC6000 (an acrylic polymer and wax emulsion) has also been used to improve the appearance of a paper mend. (see 18.3.3.D) Japanese paper adhered with PVA dispersions mimic parchment very well in flexibility and texture. When toned with acrylics the repairs can be virtually indistinguishable from the original.

When adhering Japanese paper with PVA a medium viscosity seems to work best. If too thick, the adhesive is difficult to handle and doesn't seem to improve the transparency of the repair. If too thin, the Japanese paper doesn't become as transparent as with the thicker solutions. At the Folger Library, Klucel G in ethanol is used in combination with the PVA method, after applying the tissue to the parchment a coating of Klucel G is applied to the surface and the tissue is then rubbed down. As the mend progressively dries, further Klucel G is applied; this acts as a lubricant to the teflon folder being used and it seems to make the repair less visible, frequently negating any need to tone the paper afterwards. If inpainting is needed acrylics seems to work well. (Note this method of repair is suitable only for finished parchment surfaces; it is not intended for the soft nap surfaced parchments.)

F. Western Paper

Many flat parchment artifacts have been infilled in the past using western paper. Often they are reasonably attractive in appearance, secure in attachment, and have not created any puckering or other deformity over many years. However, innumerable cases have also been seen where Western paper used to infill parchment has caused severe puckering and distortion. There are examples in the New York University's Conservation Program sample collection students. (JFM) Therefore, since current opinion diverges, the use of Western papers for repair should be carefully considered.

G. Adhesive-Coated Tissues and Membrane (Solvent-Activated)

1. Heat-set Tissue: Library of Congress heat-set tissue can be used for simple repairs of parchment. It can also be used as a temporary repair during tensioning. This material is the only heat-set tissue which at this writing that has been thoroughly evaluated for archival stability. Both LC Heat-set and the leafcast Gossamer Tissue are commercially available. The chief difference in the use of these papers for parchment repair is that heat cannot be used to activate the adhesive due to potential damage to the parchment

(see 18.2.5.B). Instead the tissues are activated by wetting out with either ethanol or acetone depending on the nature of the adhesive and media, positioning the tissue, lightly burnishing through a protective layer of non-woven polyester web, and then weighting it to maintain contact until dry. This provides a mend that is unobtrusively translucent and may be suitable for areas where soluble media preclude the use of aqueous adhesive. The mend is not aggressively strong, but where increased strength is desired its light weight and translucency suits it for use on both sides of a skin. The Gossamer Tissue is often selected for its aesthetic qualities in lieu of animal membrane. When used for overlaying damaged areas of text or illumination (in particular to both sides of the piece) the tissue will provide support without the visual distraction (sheen) that other materials like fish skin and goldbeater's skin can have.

2. Heat-set Membrane: Heat-set adhesives can also be cast onto animal membranes such as goldbeater's skin, or even parchment which has been thinned, for unobtrusive mends which can also help hold degraded, crumbling surfaces of a skin together. Heat-set membranes are not commercially available, and have to be prepared in the conservation workshop. (See Cains, 1992.)

H. Combinations of Above

1. Parchment and Transparent Membrane: Parchment is sometimes used in combination with animal membrane when large inserts require stronger adhesion to the original. By allowing the membrane to extend beyond the parchment fill, it provides an overlap which is secured with an appropriate adhesive to the borders of the loss. Alternatively, strips of membrane can be attached only to the borders of the parchment infill in order to secure it in place. Another technique which is described by Anthony Cains in Repair Techniques for Vellum Manuscripts (see bibliography) is to build up a three-layered stepped membrane flange in which the middle layer will fit inside the bevel of the new parchment and the outer membranes will extend beyond its edge. The infill can be secured in position with one overlapping membrane secured to the front of the artifact and one secured to the reverse. Using transparent membrane in this way should not obscure text that is overaid.
2. Japanese Paper and Membrane
    a. Technique currently used by Nancy Southworth and Marnie Cobbs which uses gelatin to laminate Japanese paper and goldbeater's skin. They have also used Jade 403 to laminate Japanese paper and goldbeater's skin.

I. Pulp Fills

1. Technique using Purified Hide Powder: This pulp filling technique was recently developed in Belgium (Royal Institute for Cultural Heritage, Brussels) by a group of scientists and conservators responsible for the treatment of an early medieval illuminated manuscript on parchment. The manuscript had been severely damaged by mold and by a careless restoration that was carried out in 1957 (Wouters, et.al., 1990, 1992 and 1993). In this process an aqueous suspension of purified hide powder is

prepared in 0.03% Tylose MH300. Mild pretreatment with formaldehyde and additional calcium carbonate may be used to tune the opacity of the final preparation. Since the Tylose will be eliminated during casting on the suction table, no materials foreign to parchment will be present in the final dry reconstituted parchment. The pulp mixture is not toned in any way prior to use.

The repair work is carried out on a custom-built suction table provided with a totally porous polyethylene cover plate. Illumination may be provided by a bank of flourescent lights below the table. An ultrasonic humidifier with a hose attachment is available nearby, for the local humidification of the original parchment during pulp filling. The parchment is relaxed for a short time using the Gore-tex sandwich technique. An area slightly larger than the one to be filled is cut in a polyethylene sheet. On top of this is placed a piece of polyester web and then the parchment. With the suction table turned on the liquid pulp suspension is cast on to the area of loss by pipetting. The progression of the casting and the local humidification of the damaged parchment may be easily followed by the lighting provided from below.

Upon drying, the pulp may shrink by 2 to 5%. Therfore, sufficient overlapping between pulp and original parchment should be provided in order not to loose the bonding between both materials. The total amount of pulp material needed may be calculated beforehand. Once the pulp fills have been cast the area is dried under local pressure, between polyester web, blotters and weights. Infills at the edges are given the same thickness as the original surrounding parchment. Central perforations are cast with reduced thickness to compensate for shrinkage upon drying. The suppleness of the dried pulp is high. The bonding with original parchment may be strengthened by covering the binding area with goldbeater's skin, without any adhesive.

Any discoloration or dimensional changes in the dried pulp could not be detected after several ageing experiements, involving exposure to varying degrees of relative humidity and illumination. (JW & LW)

2. Technique using Hide Powder and Eukanol Glanz N: This method of pulp filling was originally developed by Per Laursen, a paper conservator in Denmark, and is currently practiced in his workshop and also at the State and University Library in Bern, Switzerland. (Laursen, 1985). The technique is especially appropriate for parchment artifacts which are heavily damaged (by mold or fire) in areas of writing or illumination. The advantages are that there is no water involved in the actual application of the pulp. However, if the dried pulp fill needs the additional support of a layer of goldbeater's skin, an aqueous adhesive is used for its attachment. With this method the fill material is limited only to the area of loss and does not overlap to any extent on to the original. The disadvantage is that large areas of cast pulp can often be very stiff in comparison to the rest of the treated artifact.

   Pieces of blotting paper and polyester web are placed on a suction table and the parchment artifact is set on top. The whole surface is masked with strips of polyethylene, leaving an open space around the losses. While the suction

table is turned on, the parchment powder is sprayed evenly onto the losses, either with a mini-vac cleaner converted to a blower or with a flock-spraying jet. Excess powder is gently wiped away from the areas around each loss using a soft brush. Before impregnating the fill with a binding agent the parchment powder must be fixed in place with a spray application of ethanol. After placing a transparent strip of polyethylene over the area, the layer of powder is smoothed down with a bone folder.

The binding agent, Eukanol Glanz N 103 543, is then applied to the fill with a brush. This is a synthetic casein product which is diluted with ethanol to make a 40% solution. (see section 18.3.3.G.2 Mending, Filling and Lining Materials: Pulp Filling Materials) Depending on the condition of the original parchment, this solution could be further diluted up to 50%. (The use of more dilute solutions of Eukanol make the final pulp fill more supple and brighter in color once dry.) After about 10 minutes of drying on the suction table the artifact is removed, using the polyester web below as a support. The object is placed in a sandwich of clean polyester web and blotters to dry under slight pressure for about 12 hours.

If the area of loss is large, the pulp fill usually requires some additional support. This can be done by covering both sides of the fill with goldbeater's skin, while the object is held in place on the suction table. The transparent membrane is first degreased (see 18.3.3.B.2a) and then lined with polyester web as a temporary support (see 18.3.3.B.2c). The shape of the loss is cut out of the goldbeater's skin/polyester web laminate with an overlap of about 3 mm, depending on the condition of the original parchment in the area of loss. The mend is pasted out and adhered skin side down to the pulp fill using a 1:1 mixture of parchment size and wheat starch paste. (The suction is turned on at this point, in order to prevent the artifact from cockling with the application of the aqueous adhesive.) The goldbeater's skin is smoothed in place using a bone folder. The polyester web is then peeled away from the membrane, the artifact is turned over and the opposite side is treated in the same manner. Finally, the artifact is dried for several days under slight pressure, with the blotters changed at regular intervals to speed up the drying process.(UB)

3. Technique using Parchment Powder and Ftorlon: This technique, which was developed in the former Soviet Republic, is used primarily for the repair of mold-damaged parchment manuscripts. (Margotieva and Bykova, 1992) A fine powder, made from grinding and sifting new parchment, is mixed with a 5% solution of Ftorlon 26L in 1:1:1 ethyl acetate/butyl acetate/acetone to make a pulp. (This adhesive, which is presently favored by many Russian conservators for the repair and consolidation of parchment, consists of a copolymer of fluorolefins. See section 18.3.1.D Adhesives and Consolidants for further details.) The parchment pulp is applied to the area of loss while working from the reverse side of the artifact. After most of the solvent has evaporated the fill is covered by "a specially prepared film of Ftorlon" and then dried under weights. (Margotieva and Bykova, 1992, p.4)
4. Technique using Hide Powder and Paper Pulp: This pulp-filling method was developed at the National Library in Budapest, Hungary as a means of

repairing an important collection of illuminated manuscripts on parchment that had been severely damaged by mold. (Beothy-Kozocsa, et.al., 1987 and 1990) The pulp contains a wide variety of materials including hide powder, paper fiber, parchment size, hydroxyethylmethylcellulose, water, ethanol, isopropanol and a fungicide called Preventol CMK. (See section 18.3.3.G.4 Mending and Filling Materials: Pulp Filling Materials for further details on the contents of this pulp.)

Three different methods are used in the application of the pulp, depending on the condition of the original artifact. In the first method the manuscript leaf is lightly sprayed with an ethanol/water solution and left to humidify for several minutes between damp blotters. Once relaxed, the leaf is laid in place on a custom-built suction table, which is covered with a nylon screening cloth and then with a piece of Diolen - a fine silk fabric similar to crepeline. With the suction turned on, and with illumination provided from below, the pulp is cast on to the areas of loss using a flexible plastic bottle fitted with a top that resembles an eye dropper. Once the casting process is completed on a single leaf the suction is turned off and the parchment is covered with another layer of Diolen fabric, followed by two sheets of blotter and a pressing board. After about 10 minutes the artifact is removed from the suction table and transferred to a table top where drying under pressure is continued, with successive changes of blotters and a gradual increase in the amount of weight that is applied.

In the second pulp filling method practised in Budapest a layer of pulp is cast in a roughly circular shape on to a support of Diolen fabric, blotting paper and felt. After a few minutes most of the moisture in the cast pulp is removed by light pressing with blotter paper. The "sheet" of damp pulp is then carefully removed from the support and applied to an area of loss on the original parchment, which has been slightly humidified using the techniques described above. The pulp fill is pressed in place with the fingertips and/or a bone folder and the artifact is then sandwiched between Diolen fabric, blotters and pressing boards for final drying under pressure. In the third method small discs of pulp are cast on to the fabric/blotter/felt sandwich as before, yet this time they are allowed to dry completely under pressure. Once dry the cast pulp is applied to a completely dry artifact, using paste around the edges of the losses for the attachment of the fills.

18.4.12 Lining (see AIC/BPG/PCC 29. Lining)

Lining is rarely needed and seldom carried out for parchment artifacts. Probably the most likely occasion for lining would be in the case of weak, perforated, or degraded (i.e. mold-damaged) parchment. Normally, parchment is too strong to require the structural reinforcement of lining, and lining can drastically alter the character of parchment. Also, parchment is more penetrable to most adhesives, and the adhesive can not be removed again through immersion techniques. As discussed above, severely weakened parchment may be better served by consolidation or encapsulation, or by benign neglect.

If, however, the decision is made to line a parchment artifact in the tradition of paper conservation using wheat starch paste, the hazards of exposing it to excessive moisture

must be born in mind. (see 18.2.5.A) These same hazards render the reversibility of a paste lining problematic at best. Humidifying a parchment artifact before lining is risky, because its softened surface will form a more permanent bond with the adhesive and lining material, and render it more susceptible to gelatinization or transparentization during pressing. In most cases the lining paper would have to be applied in the traditional stick-and-brush method with dry paste (see AIC/BPG/PCC 29. Lining 4.1&2) in order to conform to the undulations of the artifact. The artifact must be dried with careful attention to the dangers of excessive pressure (see 18.2.5.B) when it is dried under pressure, or it can be dried on the suction table. The lined parchment must not be allowed to "air dry", or it will be permanently deformed.

Parchment artifacts have also been lined in the past using non-aqueous adhesives such as heat-set tissues. These lining materials usually require the use of overall application of either solvent or heat, both of which can be harmful (see 18.2.5.D and G). Solvent or heat may also be required to remove these linings. Moreover, most conservators of parchment would find these linings aesthetically unacceptable, so this practice is now viewed as outdated.

18.4.13 Housing

A. Considerations in Housing Parchment Artifacts

1. Size and shape of object: bulkiness or weight of object or its attachments, thinness or thickness of the sheet
2. Format: multiple superimposed sheets (must all sheets be available for easy reference?), multiple contiguous sheets, sewing/lacing/binding, attachments, fold-overs, integral mounts (e.g. original stretchers, Portolan chart boards)
3. Physical condition: state of degradation (integrity or strength of the sheet); friable media, coating, or parchment surface; mold; responsiveness to humidity fluctuations; extent of cockling)
4. Future use: exhibit, research, reference, legal, or combination of the above
5. Storage/Display Environment: are the environments stable or will the parchment be exposed to extremes, ie. fluctuations in humidity and/or temperature? (see 18.4.14 Storage and Display)

B. Polyester Film Encapsulation and Sleeves

Polyester film encapsulation is the sealing of an artifact on all four sides between two sheets of transparent polyester film suitable for archival use such as Mylar-D. The films are bonded only to each other (either along the edges or at a seam) and not to the artifact. A polyester film sleeve is sealed only on two adjacent sides or on three sides. This option is often chosen for artifacts which are to be periodically removed from the sleeve, and is especially useful for multiple-sheet documents where access to all the sheets must be readily available. Housing an artifact inside a sleeve affords considerably less protection from environmental influences and is often unsuitable for highly cockled parchments, which can slip out more easily than flatter artifacts. Provided there is no information on the verso a leaf of archival bond or light weight mat board can be placed behind the parchment for additional support. Nevertheless, the presence of open sides on a polyester sleeve necessitates somewhat more care in the handling of the artifact by researchers.

Polyester film encapsulation is a relatively easy and cost-effective solution for effectively protecting parchment from rapid humidity fluctuations, and it provides minimal physical restraint against cockling. It should be carried out when the ambient relative humidity is satisfactory, and with documents that are relatively flat. Cockled documents will cause an encapsulation to have more pronounced distracting reflections. In the extreme case it may be physically impossible to weld polyester film together near the edge of a very cockled item. Some custodians find all encapsulations aesthetically unacceptable, particularly for artifacts that are to be displayed. For research and archival material, however, encapsulation is invaluable for protecting an artifact from negative environmental influences and from the inevitable stresses and contaminations of handling.

Sealing parchment inside an encapsulation has not been shown to cause accelerated chemical deterioration as is the case with encapsulated acidic paper. Just as with paper, however, housing of parchment in polyester film is not recommended when flaking or powdery media, coating, or support is present, because of the electrostatic attraction of the film.

Encapsulation of documents with substantial attachments is difficult. Within the encapsulation pendant seals can be supported with ultrasonic spot welds. When they are extremely thick and attached at a distance from the artifact they can be allowed to protrude outside an encapsulation. Of course in the latter case the entire document will require a secondary support or housing. (see 1.4.13.E Problems in Housing Parchment Artifacts with Pendant Seals)

Three methods of encapsulation currently in common use are: ultrasonic welding, heat welding, and adhesion with double-sided pressure-sensitive tape. Heat welding could be problematic because of the high temperatures used in close proximity to the artifact, the solution is to leave more space between the document and the seal. Double-sided tape produces the least attractive package, and exposes the artifact to possible future contact with the sticky adhesive. It is also possible to join two sheets of polyester by means of sewing with an industrial sewing machine. For encapsulation of extremely large oversized collection materials staff at the Library of Congress have come up with a method of using the Ultrasonic Welder to seam polyester film. The largest width of polyester film available on rolls is 60" (from Taylor Made) which in many cases cannot accomodate oversized posters and maps. Using the Ultrasonic Welder, the polyester film is rolled like a scroll to fit under the bridge. The challenge lies in preparing the material to fit in the frame under the horn while keeping the polyester free of dimples, creases and scratches. Information on this method will be presented by Carol Paulson and John Bertonaschi, in a poster session at the annual AIC Meeting in Nashville, Tennessee, June 1994. A printed copy of this information is available by a written request addressed to the Phased Section in the Conservation Office of the Library of Congress.

C. Window Mats (See also AIC/BPG/PCC Paper Conservation Catalog 40. Matting and Framing)

Sometimes documents, especially those that are several centuries old, were marked on the reverse with annotations and stamps with historical or legal importance by owners, officials, and archives. Such evidence should be available for viewing and

study by scholars, even while the artifact is mounted in a window mat. To this end, it has been suggested that the document be attached to the reverse of the window mat, instead of to the backboard.(HS) An alternative solution would be to cut a window in the backboard and adhere a piece of transparent polyester film over it. A deeper window mat is generally needed to accommodate the thickness and movement of a parchment sheet.

1. Object Secured in Encapsulations or with Polyester Film Corners, Slings, and Straps: If an artifact is encapsulated it can easily be secured to a window mat backboard using double-sided tape. The window can be cut to a size which reveals the entire document but conceals the weld or join of the polyester. Reflections from the polyester will always be discernible to some extent, however, and some custodians will find this aesthetically unacceptable.

   Polyester corners, slings, and straps have the advantage that they can be overmatted (unless the artifact must be "floated" in its mat) and would therefore not disturb the viewer. They do not require any adhesion or attachment directly to the artifact. These systems are not appropriate for very cockled pieces or for artifacts with friable paint. There is also the risk that a humidity-responsive parchment will pop out of its restraint when excessive movement occurs in an uncontrolled environment.

   The polyester film sling mount, described more completely in Matting and Hinging Works of Art on Paper, Library of Congress, 1981, could be considered appropriate under certain situations. Polyester film circles, about 1" in diameter, are folded in half and placed at the edges of the artifact. A piece of double-sided tape, placed on the reverse of the other folded half of the circle, allows one to secure the sling to the back mat. Polyester, polyethylene, and polypropylene films can all be used to fashion photo corners or straps as mounts for parchments. Some parchments with pendant seals which lace through a fold-up at the bottom can be held very securely to a mat with an unobtrusive strap placed under the fold-up and brought through to the back of the mat board via slits. Some give in the length of the straps and the positioning of photo corners allow for dimensional changes in the parchment. Corners and straps should not be placed over friable media. Polypropylene and polyethylene are softer than polyester and can be folded without creating a cutting edge. Polyester can be very sharp and is very shiny. Abrading it with emery paper will lessen reflections but will also make it less transparent. (EO)

2. Object Secured with Paper Hinges: A stronger or thicker adhesive is required for hinging parchment with paper hinges than is necessary for most paper artifacts. The hinge must be weighted for a considerably longer time in order to avoid puckering or cockling of the parchment; the hinges should never be dried using a tacking iron (see 18.2.5.D). Hinges which are too thick can leave an impression and/or cause puckering over time.

   Hinging only across the top of a parchment artifact is insufficient for all but the thickest and least humidity-reactive parchment. Most parchment must be hinged also at the bottom, and perhaps at the sides as well (see below). Otherwise a "floated" sheet may move forward in the window, perhaps

touching the glazing, and a slightly over-matted parchment could escape from underneath the window. When hinges are placed at opposite ends of a document they must not pull the sheet taut, but should allow sufficient movement to avoid creating draws in the sheet or tearing the hinges when the parchment contracts.

Solvent-activated adhesive-coated tissue can also be used as a hinging material, as long as heat is not used to attach the hinge (see 18.2.5.D and 18.4.11.G Adhesive-Coated Tissues and Membranes).

3. Object secured with Paper Straps: This mounting system is especially suitable for large documents. It was designed for temporary exhibition and for archival rather than fine art materials. It will function well in any relatively stable environment, the important requirement being the built-in break-point which allows the parchment to detach from the support board if it is placed under excessive tension. The requirements of a mounting system for such material are necessarily quite simple, and must simply be able to perform satisfactorily on a large scale, be strong enough to restrain the skin under modest fluctuations in relative humidity and allow a little movement as it does so, yet at the same time not be so strong as to threaten to split the skin if it shrinks significantly in overly dry conditions.

The support board

The support board needs to be rigid, light in weight and chemically stable. Acid-free honeycomb board can be used, or sheets of multi-purpose acid-free double-wall corrugated board (E-Flute). If corrugated board is used it should be lined on both sides with 4-ply museum board to provide dimensional stability and a smooth surface. A single sheet of the corrugated board will be sufficiently strong for smaller items, and extra sheets can be laminated together with PVA for larger material. To finish the board, it can be 'wrapped' in acid-free paper adhered with a finely sieved wheat starch paste. The "wrapper" should be taken over the cut edges of the corrugated board to hide them. The resulting board is comparatively lightweight and very rigid.

The mounting system

The sheet of parchment is held to the support board by straps of long-fibered Japanese tissue, the weight and width selected according to the size and weight of the skin to be mounted. The strap width normally used is in the range 5-10 mm and sufficient straps are cut to allow them to be placed perpendicular to the edge of the document at intervals approximately equal to their own width. This close spacing keeps the edges of the parchment under control, provides enough strength to hold it under sufficient tension and avoids the risk of distortion which might result from adhering a continuous frame to it. The length of the strap varies according to the size of the skin, but 100-150 mm accommodates most material. At the corners, L-shaped straps can be used, which avoids having two thicknesses of Japanese paper at these points. The tissue straps are secured to the verso of the skin with a stiff wheat starch paste, attaching no more than 5-10 mm of the strap to the skin. The other end is secured to the back of the mount with PVA. The length of the straps is intended to allow some lateral movement

as the skin expands and contracts, and the tissue paper itself is able to stretch (though not recover) to compensate for a certain amount of shrinkage.

Should the skin shrink too much, the straps will either pull apart or tear along the edge of the support board, thus releasing the skin from further tension and preventing damage. If the skin does not cockle too much when this happens, it is possible to repair the mounting merely by replacing the torn straps.

Attaching the skin to the mount

This work should ideally be done at the same humidity level as the place where the mounted item is to be hung or exhibited. If this environment cannot be achieved within the workspace, then it is best that the item should be mounted in the location where it is to be kept.

It is important, having found the best position for the skin on the support board, to make sure that it is not shifted in the course of attaching it. This is most easily accomplished by placing the support board recto upwards on a block sufficiently high to give easy access to the underside around the edges. With the skin in the correct position, and held from moving by weights, stiff PVA is applied to the underside of the straps in the center of each side. These are then carefully molded around the edge of the support board and stuck to the underside, taking care to smooth them across the board before sticking down the glued ends. The corner straps can then be similarly glued down. Once the corners and centers of each side are secured, the mount, with the attached skin, can be carefully turned over onto clean paper or blotters and the rest of the straps can be glued in place. The straps at the corners need to be 'woven' over and under each other so that no strap is glued on to another. This can be achieved by gluing them down in the right order .

Framing the mounted skin

Once the assembly is complete, steps must be taken to protect the straps around the edge of the mount or they will be damaged by handling. If the assembly is to be framed, then the frame can be used to give this protection by allowing a small gap between the edge of the mount and the inside of the frame.

The mount itself can be attached to the backing board of the frame via strips of Velcro to give an easily dismounted assembly, or, more simply, via blocks of single wall corrugated board, glued with PVA to both the back of the mount and the backing board of the frame. Should the mount ever need to be removed, the corrugated board can easily be split apart. It is important that the Velcro or the corrugated board are attached without overlapping any of the mounting straps, and that the straps themselves are not in contact with the backing board. The Velcro and the corrugated board will both ensure this.

So as to avoid the risk of the skin expanding and touching the glazing or to prevent loose or friable pigments from being dislodged by the static pull of the glazing material, a space of 10 mm to 20 mm should be left between the

surface of the object and the frames glazing. If a glazed frame is not required, a shallow tray, the edge just deeper than the combined thickness of the mounted skin and the Velcro or corrugated board attachment can be used instead. It can be provided with a lid for secure, dust-free storage if required.

Mounting irregularly shaped skins

Square or rectangular support boards, cut slightly larger than the maximum width and height of the skin, work well with most material, which if it is not exactly square, is usually not far off, and the straps, if similar in color to the paper used to line the support board, need not be visually intrusive. A gilt fillet inside the frame under the glass or Plexiglas will mask the edge a little if required. However, material which is not at all square will need to be mounted on boards cut approximately to the shape of the skin to be mounted. This need not follow every exact contour of a highly irregular edge, and the straps can be masked with a more accurately shaped window mat if necessary. Alternatively, a special support board, made up of three or more layers of museum mounting board, glued together with PVA with the grain of each layer at right angles to the previous one, can be cut to the exact shape of the skin, bevelled on the underside, so that the mount will be all but invisible under the mounted skin. It is attached to the backing board or tray in the same way, and the same strapping arrangement is used, only here the straps are attached at right angles to the edge of that part of the skin to which they are pasted, and not in the neat parallel arrangement which is used for square and rectangular skins.

Conclusion

This method of mounting larger pieces of vellum or parchment for display or storage is not intended to be a perfect solution to the problem of securing such a highly hygroscopic material as parchment. Parchment's capacity for movement in response to changes in humidity levels is greater than the straps can possibly cope with, but provided that the mounted skins are not exposed to excessively dry conditions, the straps will secure the skin without exposing it to too much tension, and should the humidity levels rise, the skin will still be held around its edges, even though the tension of the mounting will be released. When the humidity levels return to normal, the skin will once more pull itself flat between the straps. Should it be necessary, the skin can be removed from the mount simply by peeling the straps away from the skin, dampening them lightly from the back if necessary. (NP)

4. Paper/False Margins

   a. Method used at the J. Paul Getty Museum: First suggested by Keiko Keyes for mounting double-sided, Old Master drawings, this method has been successfully used for mounting small manuscript fragments on parchment, particularly in cases where the design layer extends to the cut edge on the recto or if there is text or design on the verso.

      The paper selected for use in the mount should be of the same thickness as the parchment cutting or fragment being mounted (use a paper thickness

gauge), usually a medium-heavy weight Western handmade paper. The inner edge of the paper margin is cut approximately 1 mm beyond the edges of the object, so that there is a slight gap between the parchment edge and the paper margin; the width of the margin is discretionary (2"-4" in width as required.)

Thin strips (4-5 mm in width) of fine, long-fibered Japanese tissue (such as Kizukishi) are torn in separate lengths to correspond to each edge dimension of the fragment. The torn-edge strip of Japanese tissue is then pasted with rice starch paste and adhered to the verso edge of the cutting and the inside cut profile of the paper margin, bridging the 1 mm gap. The Japanese tissue need adhere only 1-2 mm or so onto the verso edge of the object, keeping the amount of paste to a minimum. A sufficiently strong attachment is made if only the fibrous edge of the tissue is pasted onto the object. The pasted edges are weighted between blotter and hollytex to dry. Once dried, the pasted, fibrous edges of the tissue become virtually transparent.

Once the attachment to the paper margin is complete, the whole can be mounted in either a single or a double-window mat, hinged, or mounted in place with photo corners. This mount allows the fragment to be float matted with a 1/4" margin so all edges are visible, and over-matting can thus be avoided (this is particularly important if the design layer extends to the edge of the support or if the support is badly cockled). Moreover, the window of the mat, when closed, puts pressure on the paper margin, not on the leaf itself, holding the entirety in plane.

If the object experiences RH change, the mount will react with the piece and not against it. By leaving the gap between the paper margin and the object, the object still has room to move. Moreover, since the paper margin is not a heavy card but a paper of comparable thickness and flexibility to the parchment, the mount will not act as a rigid constraint, as in the traditional drum mount technique. Therefore, any stress or strain will be acted upon the Japanese paper strips that bridge the gap between the object and the paper mount, not on the weakest area within the object itself.

The addition of paper margins to a manuscript fragment (a) prevents readers from handling the leaf directly, (b) keeps the fragment in plane and prevents the parchment support from curling, particularly if the cutting has been removed from a backing and may have residual adhesive on the verso or if the paint layer on the recto surface is thickly applied, and (c) can be easily replaced if soiled or damaged.(NT)

b. This mounting system uses false margins of japanese paper within a window mat. It was developed by Library of Congress staff as an alternative to string mounting (which is one of the primary methods of housing parchment at LC).

The principles behind string mounting (ie. movement with the object and detatchment of the string if the tension becomes too great) defined the approach when developing this mounting method. The string mounting system works best when held in rigid housing such as plexiglass

sandwiches or frames. For materials that will not be kept in ideal environmental conditions or for those that are in a mat that cannot provide a rigid support, the false paper margin mounting method is designed to avoid the need to re-enter the housing when a string pops off.

The principles of tensioning all around to emulate the manufacturing process and the use of an attachment material which will expand and contract as well as give-way first can be accomplished by using a modification of the Japanese scroll mounting technique (designed for drying objects on a drying board). This technique adheres false margins all around the edge of the object. For parchment objects, the paper margins are then slit at regular intervals. Without the slits, the paper margins cannot move and respond along with the parchment.

Select a Japanese paper which is aesthetically compatible with the object, but lighter in weight. Make the margin strips by tearing the grain long Japanese paper about four or five inches longer than the length of each side of the object and approximately one and a half to two inches wide. The margins may require shaping to the contour of the parchment. To attach the margins to the object, adhere the feathered edges to the perimeter of the verso, centering the object on the margin so that the extra lengths of paper extend equally. Working one half inch away from (and parallel to) the edge of the object cut inch long slits, every other inch, in the paper margin. Move one inch away from the object (half an inch from the cuts) and create an alternating pattern by making a second row of slits (parallel to the first row).

The paper margins are then adhered to the back mat board only along their outer half inch. Gelatin tends to make the tissue feathers transparent and is likely to expand and contract at a rate similar to the parchment document. Swab away any excess adhesive. This technique works well on a skin with a closed surface. As with any hinging method, open, pumiced surfaces could possibly go transparent or turn grey depending upon the characteristics of each individual skin. (JM)

5. Object Secured with Linen Threads

   a. Standard thread mat: For a good description, see Clarkson, 1987, pp. 201-209.

   b. Reverse thread mat: The reverse thread mat requires a mat cut to more than twice the width and height of the piece of parchment to be mounted, as the combined lengths of any two threads placed opposite each other around the edge of the object should be approximately equal in length to the width or height of the object between those two threads. This becomes a problem when miniatures or other drawings and paintings on parchment need to be remounted but still have to fit into existing frames or exhibition spaces.

   One answer to this problem is the reverse thread mat, in which the linen threads are taken around the edge of a specially prepared support board and held at the center of the reverse of this support board instead of

around the margins of a larger mat. The system does not allow for double-sided viewing, which the thread mat allows without difficulty, so any writing or image on the verso of material mounted this way must be photographed beforehand.

The support board

A piece of 4-ply acid-free mounting board is cut to the required size, normally larger by a margin of 1-2 mm on each side than the piece of parchment to be mounted. This is then set into a hardwood frame with a waxed and polished half-round edge, into the center of which are set small brass or stainless steel nails equal in number to the number of threads to be used to secure the piece of parchment. These pegs locate the threads as they pass around the edge of the support board and prevent them sliding towards the center of each edge; the polished edge allows the threads to expand and contract without difficulty. The back of the support board is filled in with mounting-board.

Attaching the threads

The cut lengths of bookbinders' linen thread, washed in water with a little soap, are secured to the parchment with wheat starch paste, as described by Clarkson. The object is placed face down on a sheet of clean paper on which are drawn guides to enable the support board to be placed exactly in the right position on top of it. The center thread from each side is then twisted between finger and thumb until the thread, held under light tension, begins to kink; it is then untwisted until the kink disappears, and the loose end of the thread is secured to the center of the back of the support with stiff PVA. The extra twisting increases the change in length of the thread in fluctuating humidity levels. As soon as these four threads are secure, the remaining threads can be attached in the same way, making sure that they are hooked over the correct brass peg. Care must be taken not to rotate the parchment during this process by pulling more firmly on some threads than others. Where miniatures cut from manuscripts with very uneven edges are being mounted, it will often be necessary to vary the angle of the thread attachment to suit the shape of the fragment.

An alternative approach is to twist the linen thread until it kinks a lot and then stretch it out, set the frayed end down with the PVA and weight it. This creates sufficient tension on the parchment, which is evidenced by one one particular piece which held its planarity for 17 years after having traveled for three years on exhibit. (JFM)

Attaching the support board to a frame

The support board must be held away from the board to which is it attached, and this is done by securing it with brass or stainless steel screws passing through the board, through spacing washers and into the wooden frame of the support board. The whole assembly can then be framed, making sure that there is at least a 5 mm gap between a small (100 mm x 100 mm) piece of parchment and the glass, the gap increasing as larger pieces of parchment are framed. If Plexiglas is used to glaze the

frame, a wider gap may be necessary to avoid the risk of friable pigment being detached from the surface of a painting by static pull.(NP)

D. **Problems of Housing Multi-Sheet Documents**

1. Research/reference materials
2. Display/exhibit materials: It is very impractical to exhibit sheets other than the top one in a multi-sheet document. It may be possible to roll back the upper sheet/sheets and restrain them with polyester straps joined with double-sided tape or with very wide cotton twill tape ties to display a lower sheet.

E. **Problems of Housing Artifacts with Seals and Ribbons** (see Szczepanowska 1992 and Burns and Bignell 1994)

Seals are either applied directly on the document or are hung from lengths of cord, parchment, or ribbon. Documents can be sealed with one or more seals, made out of wax, resin, paper or metal. Some seals are protected by metal or wooden skippets, and some are without protection. Every seal and its method of attachment are integral elements of the document, and must be taken into account when devising appropriate housings for their storage and display. Many require solutions that are very individually suited to the needs of a particular artifact.

The thickness of seals and ribbons must be accommodated in a window mat or in a sunken backboard/mount. A container for a seal can be attached to the surface of the mat (with a spacer placed on the mat), or between the window and the backboard. They can also be housed in a sunken compartment in a built-up thick backboard. Depending on their shape and placement on the document both seals and ribbons may require awkwardly-shaped windows. Heavy seals are also best supported by tailor-made compartments within the storage container even if they are not mounted for display. Surviving original containers for important documents are constructed with such compartments.

One housing system used for a large detached pendant seal at the National Archives consisted of a three-dimensional construction of archival corrugated board crimped with the direction of the corrugation to form a circular receptacle slightly larger than the seal. The corrugated board was two layers thick, lined on the inside with Nalgene 1/8" "clean sheet" expanded polyethylene. The composite was then covered with Japanese paper applied with wheat starch paste. The construction was slightly deeper than the thickness of the seal. A gap could have been left for any ribbons present. This construction can be used for long-term storage or for exhibit (with proper build-up of the window mat to the height of the construct) and can be attached to a rigid support or back mat with an appropriate adhesive. The outer covering of Japanese paper makes an unobtrusive presentation, and is usually close in color to mat board. (EO'L)

When an artifact with attachments or seals is encapsulated, the polyester should be welded close to and along the bottom edge of the artifact, up to the strap from which the seal hangs. This weld is important for helping to support the edge from which the seal hangs, so it is less likely to stress or deform that area. Additional welds or spot welds below and beside the seal will also help support the weight of the seal.

A housing system used for pendant seals and other large attachments can be created with plexiglas "skippets" mounted on the encapsulated assembly. Prior to encapsulation the parchment documents with seals are flattened. The document is then laid out on a large sheet of five mil mylar and a smaller second sheet (approxi-mately 25mm larger than the parchment on all four sides) is used as a top sheet. Using an ultrasonic welder the document is encapsulated on all four sides except where the ribbon, strap or thread extends to which the pendant seal is attached. A plexiglass skippet is fabricated from plexiglass tubes which are available from plastic suppliers. As they come in varying diameters, select one which is slightly larger than the seal. Creat a disk by cutting a section off of the tube that is taller than the seal is thick. To accomodate the ribbon or strap cut a notch out of the disk then finish and polish the edges. For a back plate cut a piece of 1/16" plexiglass sheeting that is slightly larger than the disk, bevel and polish the edges. Using a small drill bit that matches the size of brass escutcheon pins, drill holes every couple of inches through the back plate and into the bottom edge of the disk (the plexiglass tubes come in various wall thicknesses, the thicker the better to accomodate the pins). The large bottom sheet of mylar which supports both the document and the weight of the seal will be sandwiched between the back plate and the disk. The seal is placed into the plexiglass skippet and the back plate is pinned into place on the underside of the mylar, the pins can be adhered in if they are a little too small. The seal is then cushioned around the sides with strips of felt to prevent the seal from moving around in the skippet. This method of housing allows a document and seal to be safely and easily viewed from both sides, and is light weight and not bulky. (JFM)

18.4.14 Storage and Display (see also 18.6.3, 5, 9)

A. Environmental Guidelines

The establishment of temperature and humidity guidelines for the storage and display of parchment must take into consideration many factors including the age and condition of the artifact, its previous storage environment, the format of its present housing, and the way in which it is expected to be used by curators, scholars and others.

Humidity standards for the storage and display of parchment have traditionally been set at around 55% RH, with an allowable variation of 5%. These environmental standards widely cited for parchment have generally been based on the high RH typical of Great Britain and Ireland (eg. 55-60% RH) (see Cains, Stolow and Thompson). However, more recent research by Eric Hansen and other scientists at the Getty Conservation Institute has determined that parchment is more susceptible to gelatin and biological attack at relative humidities of 40% and above. Therefore it has been recommended by these particular authors that if preservation of collagen is the primary consideration then parchment should be stored and displayed in an environment of 30% RH +/- 5%. In their published paper, however, the authors include the following caveats:

1. The lower RH of 30% may be harmful to composite parchment documents which have illuminations or poorly bound ink due to the different reactions to changes in RH of the various materials.
2. Parchment may buckle or curl at the lower humidities.

An additional area of concern is if the parchment is brittle at lower humidities, such as medieval and modern vellum (from Hansen's studies), damage may occur if the parchment is subject to manipulation (such as items stored in mylar or unframed mats, or the leaves of a book).(JM)

Careful consideration should be given to the application of rigid standards to old collections stored for centuries in the same environment which, although not perfect, seem to be working well for the artifacts. Therefore, before making storage recommendations first examine the existing storage conditions, if possible, determine how long the parchments were stored in those conditions, assess any problems and establish if, in fact, the environment caused the problems. (HS)

B. Sealed Transport and/or Display Packages

1. Framed Objects

This system is applicable for string mats or any framed/glazed parchment housing. If the mounted parchment will travel or will be subjected to flucuations in RH, it can be placed in a sealed package to reduce those flucuations. A material like Art-sorb can be placed within the package to provide additional protection. A sealed package consists of glazing (glass or Plexiglas) on the front, the mounted/matted object and any supporting materials (Fome-core, mat or corrugated board, etc.), then polyester film on the back. The edges are sealed by wrapping a strip of pressure sensitive tape (J-Lar - a polypropylene tape with an acrylic adhesive that has good aging properties) from the edge of the glazing (just overlapping the front) and around the edge to the polyester film sheet on the back. The edges of the mount, etc. can be protected from the tape by covering them wiwth strips of 10 pt. folder stock as the tape is wrapped around the edge. Sealed packages of this design have been placed in humidity chambers of 80-90% RH for a week and have maintained an internal humidity of 50% RH. (LP)

Another alternative backing and packaging material in use today is Marvel Seal 360. This foil barrier sheet is made by the Ludlow Corporation and sold through University Products. Note: the manufacturer's name is printed on the foil in a red ink that is soluble, for conservation use Marvel Seal 360 should be ordered without the red printing. (HP)

For more information on the success of these systems and materials see the poster session by Hugh Phibbs of the National Gallery of Art presented at the annual AIC Meeting in Nashville, Tennesee, June 1994.

Anecdotal information from Portland, OR picture framers who used gray conservation corrugated on my recommendation. On large framed pieces, the cardboard would bow out, pushing the art work away from the wall. (JT)

2. Plexiglas Sandwich

A "Plexiglas sandwich" is a housing for a matted object. It is made by sandwiching the matted object between two sheets of acrylic that are then taped together, around all four edges, with polypropylene tape (J-Lar). This sealed package system provides both a rigid structure and a relatively constant microenvironment. Parchment or paper artifacts are often placed

in Plexiglas sandwiches particularly during transport and exhibition. However, in many cases, especially for moisture sensitive parchment, these temporary housings are often retained for permanent storage.

To construct a Plexiglas sandwich place the matted object between two sheets of 1/8-1/4 inch acrylic, which are cut to the same outer dimensions as the mat. Place the assembly face up on a clean table allowing one edge to extend beyond the table top in order to tape the sides of the sandwich unit together. It is helpful to place a weight on top to keep the stack properly aligned.

Using 1-inch wide clear polypropylene tape, start at the corner (allowing some overlap around the corner) align the tape along the edge so that there will be a 1/8 inch of tape over-lapping the top acrylic sheet. The remainder of the tape wraps around the side edges overlapping onto the bottom acrylic sheet. Rotate the unit until all edges are sealed. Repeat this step for the added protection of a second layer of tape. Finish by burnishing the tape to obtain the most effective adhesion possible.

When weight, cost or additional protection from moisture is a concern corrugated polypropylene (Coroplast) has proven an effective substitute for the acrylic back panel. The polypropylene material is lighter in weight and costs less than acrylic sheeting. Furthermore, a simple experiment at the Library of Congress revealed that the corrugated polypropylene panel was actually a more effective moisture barrier.

To gain a better understanding of the moisture barring qualities, as well as, to compare the effectiveness of various sandwich materials the following experiment was conducted in the Paper Section of the LC Conservation Lab. Three 11" x 12" sandwich units were assembled according to the instructions above the only variation being the back panel material. Each unit had a different back panel of either 1/8 inch thick acrylic; five mil polyester film (Mylar), or five cm corrugated polypropylene. A humidity indicator strip, mounted in place of an artifact in each window mat was used to monitor the internal humidity which was approximately 35% RH. All three of the units were placed in a 100% humidity chamber for 19 days. Within four days the Mylar backed unit registered a 5% RH increase and ultimately registered 50-55% RH.

After 15 days, all of the acrylic sheets became warped from their one sided exposure to the humidity. The two acrylic sheets in the one unit bowed away from each other causing the tape seal to break and allowing humidity to enter the package. The Mylar and Coroplast backed units remained intact as they moved with the warping acrylic.

After 19 days the corrugated polypropylene unit registered an internal RH of 40-45% and a small area of the tape had begun to loosen. In summary, of the three backing materials the Mylar allowed the most moisture to pass through. The corrugated polypropylene panel provided an equally effective moisture barrier as the acrylic sheet backing and in contrast was also able to accomodate the warp of the acrylic top sheet preserving the tape seal. (HW)

18.5 Bibliography

A. History, Science and Technology

Abt, Jeffrey and Margaret A. Fusco. "A Byzantine Scholar's Letter on the Preparation of Manuscript Vellum," Journal of the American Institute for Conservation 28, no. 2 (1989): 61-66.

Abt, Jeffrey. "The Deterioration Mechanism in Byzantine Manuscript Illuminations of Greek Origin," AIC Preprints. Washington, DC., 13th Annual Meeting (1985): 1-14.

Alexander, Jerome. Glue and Gelatin. New York, New York: The Chemical Catalogue Co. Inc., 1923.

An Alphabetical Listing of Engravings at the Office of the Printsellers' Association, London, from 1892-1911 Inclusive. 1912. London: Printed for the Incorporated Printsellers' Association.

Anon. "Differences Between Parchment and Leather," Leather Conservation News 1, no. 1 (1983): 30.

Anon. "Indagine Preliminaire sulle Alterazioni Microbiche della Pergamena," Fausta Gallo-Alicja Strzelczyk Istituto del Restauro e della Conservazione presso l'Università Nicolò Copernico di Torùn (Poland).

Avrin, Leila. "Parchment and the Jewish Scribe," AB Bookman's Weekly (March 26, 1984): 2297-2300.

Berardi, Maria Christina. "Why Does Parchment Deform? Some Observations and Considerations," Leather Conservation News 8 (1992): 12-17.

Berger, Rainer, Nancy Evans, Jeffrey M. Abell, and Mark A. Resnik. "Radiocarbon Dating of Parchment," Nature 235 (1972): 160-161.

Biemann, Klaus, and Hubert A. Scoble. "Characterization by Tandem Mass Spectrometry of Structural Modification in Proteins," Science 237 (1987): 992-998.

Bigus, Richard, Colin Franklin, Decherd Turner and Anne Bromer. The Mystique of Vellum. Boston: Bromer Booksellers Inc. and Richard Bigus, 1984.

Bogue, Robert Herman. The Chemistry and Technology of Gelatin and Glue. London: McGraw-Hill Book Company, Inc., 1922.

Bowes, J.H., and J.A. Moss. "The Effect of Gamma Radiation on Collagen," Radiation Research 16 (1962): 211-223.

Brown, Julian. "The Distribution and Significance of Membrane Prepared in the Insular Manner," La Paleographie Hebraique Medievale, Paris, 1974, Coloques Internationaux du Centre National de la Recherche Scientifique 547: 127-135.

Burton, D., Poole, J.B., and Reed, Ronald. "A New Approach to Dating the Dead Sea Scrolls," Nature 194 (1959): 533-534.

Calabro, Giuseppe, Giancarlo Impagliazzo, and Maria Teresa Tanasi. "An Evaluation Method of Softening Agents for Parchment," Restauro 7 (1986): 169-180.

Calmes, A. "Charters of Freedom of the United States," Museum 149 (1985): 99-101.

Chahine, Claire. "Identification des cuirs et parchemins anciens a l'aide du microscope," in ICOM Committee for Conservation, Preprints of the 4th Triennal Meeting, Venice (1975) (#75/15/6): 1-6.

Chahine, Claire. "Le Parchemin," Proceedings of the International Symposium: Conservation in Archives Ottowa (10-12 May, 1988) Paris: International Council on Archives, 1989: 11-24.

Cains, Anthony. "The Vellum of the Book of Kells," The Paper Conservator 16 (1992): 50-61.

Clarkson, Christopher. "Rediscovering Parchment: The Nature of the Beast." The Paper Conservator 16 (1992).

Daniels, V. 1988. "The Discolouration of Paper on Ageing," The Paper Conservator 12: 93-100.

Dawidowsky, F. A Practical Treatise on the Raw Materials and Fabrication of Glue. Philadelphia: Henry Carey Baird & Co., 1884.

Delteil, L. Théophile Chauvel Catalogue Raisonné de son Oeuvre Gravé et Lithographié. Paris: Georges Rapilly, 1900.

di Majo, Anna; Federici, Carlo and Palma, Marco. "La Pergamena dei Codici Altomedieval Italiani. Indagine sulle Specie Animali Utilizzate," Scriptorium 39, no. 1 (1985): 3-12.

di Majo, Anna and Rossana Rotili. "Contributo alla Conoscenza della Pergamena. Studio Statistico dell'-Arrangemento Follicolare," Bolletino dell'Istituto Centrale per la Patologia del Libro "Alfonso Gallo" 39 (1984-1985): 47-56.

Dickerson, Scott M. "Notes on Parchment," Friends of Calligraphy, 1985, pp. 8-13.

Dickerson, Scott M. "Sources of Parchment," Friends of Calligraphy, 1981, pp. 18-20.

Diringer, David. The Hand-Produced Book, London, 1953.

Doty, Paul. "Proteins," Studies in Conservation 18, no. 1 (1973): 173-184.

Dyson, A. Pictures to Print: The Nineteenth Century Engraving Trade. London: Ferrand Press, 1984.

Ellement, Peter G. "A Note on the Structure of Vellum and the Effects of Various Solvents." In Guy Petherbridge, editor, Conservation of Library and Archive Materials and the Graphic Arts, London-Boston 1987 (proceedings of the Cambridge 1982 International Conference on Conservation), pp. 199-200.

Elliot, Jean, editor. Hides, Skins and Leather Under the Microscope. Egham-Surrey, 1957.

Fahey, Herbert and Peter. Parchment and Vellum. San Francisco, 1940.

Giovannini, Andréa. "Archäologie des Buches und konservierende Restauriering," Restauro 1 (1990): 43-47.

Haberditzi, Anna Therese, Herbert Stachelberger, Gerhard Banik, Fredrich Bauer, and Franz Mairinger. "Chemical Characterization of Parchment, Part 1: Sulfur-bearing Constituents," ICOM Preprints of the 7th Triennal Meeting, Copenhagen 10-14, September 1984 (#84/14): 5-7.

Haines, Betty M., Bookbinding Leather 7 (1987): 63-82.

Haines, Betty M., . The Fiber Structure of Leather, Leather Conservation Center (1981).

Haines, Betty M. "Shrinkage Temperature in Collagen Fibres," Leather Conservation News 3, no. 2 (1987): 1-9.

Haran, Menahem. "Bible Scrolls in Eastern and Western Jewish Communities from Qumran to the High Middle Ages," Hebrew Union College Annual 56 (1985): 21-62.

Haran, Menahem. "Technological Heritage in the Preparation of Skins for Biblical Texts in Medieval Oriental Jewry." In Rück, Peter, editor, Pergament: (1991): 35-43.

Harris, Roger. "Vellum, Parchment and Henry Band," The Scribe, Society of Scribes and Illuminators, London, Winter 1984.

Illustrated Catalogue of Engravings and Etchings of the Fine Arts Society. London: The Fine Arts Society, 1909.

_____. "Ink Study Suggests Vinland Map Fraud," Chemical and Engineering News (February 11, 1974): 21.

Jackson, Donald. The Story of Writing. New York: Taplinger Publishing Co., Inc., 1981.

Jenkins, Penny. "Printing on Parchment or Vellum," The Paper Conservator 16 (1992): 31-39.

Jenkins, Penny. "Vexed by Vellum Papers," The Paper Conservator 16 (1992): 62-67.

Johnson, Richard R. "Ancient and Medieval Accounts of the 'Invention' of Parchment," California Studies in Classical Antiquity 3 (1970): 115-122.

Johnson, Richard Ronald. The Role of Parchment in Greco-Roman Antiquity, dissertation University of California, Los Angeles, 1968.

Johnston, Edward and William Graily Hewitt, Writing & Illuminating, and Lettering, London, 1906 (The Artistic Crafts Series of Technical Handbooks, ed. by W.R. Lethaby).

Kahle, T.B., Niccolo Caldararo, Stephen Weiner, Zina Kustanovich, Emanuel Gil-Av and Wolfie Traub. "State of Preservation of the Dead Sea Scrolls," Nature 321 (1986): 121-122.

Karmas. Endel. Sausage Casing Technology. New Jersey: Noyes Data Corporation, 1973.

Kite, Marion. "Gut Membrane, Parchment and Gelatine incorporated into Textile Objects, The Paper Conservator 16 (1992): 98-105.

Kozlov, P.V., and G.I. Burdygina. "The Structure and Properties of Solid Gelatin and the Principles of Their Modification," Polymer 24 (1983): 651-666.

Lambert, S. The Image Multiplied: Five Centuries of Reproductions of Paintings and Drawings. London: Trefoil Publications, 1987.

Leffmann, Henry, and W.A. Davis, eds. Allen's Commercial Organic Analysis. Philadelphia: P. Blakiston's Son & Co., 1910.

Library of Congress. Printing on Vellum, Washington, 1977.

Lister, R. Prints and Printmaking. London: Methuen London Ltd, 1984.

Lugt, F. Les Marques de Collections de Dessins & d'-Estamps. Amsterdam: Vereenigde Drukkerijen, 1921.

McCrone, Walter. "The Vinland Map," Analytical Chemistry 60, no. 10 (May 15, 1988): 1009-1019.

Merrifield, Mrs. Original Treatises, Dating From the XIIth to XVIIIth Centuries on the Arts of Painting. London: John Murray, 1849.

Nomura, S., A. Hiltner, J.B. Lando, and E. Baer. "Interaction of Water with Native Collagen," Biopolymers 16 (1977): 231-246.

Olin, Jacqueline S. "The Vinland Map - A Case Study," Proceedings: First Georgetown University Conference on Surface Analysis (1970): 25-39.

Petushkova, Yu.P. and G.M. Nikolaev. "Nuclear Magnetic Resonance Study of Parchment and Leather," Restaurator 5 (1983): 242-248.

Poole, J.B. The Nature, Origins and Technique of Manufacture of Those of the Dead Sea Scrolls Which are Made of Animal Skins, Ph.D. Thesis, University of Leeds, Leeds, 1959.

Poole, J.B., and Ronald Reed. "The Preparation of Leather and Parchment by the Dead Sea Scrolls Community," Technology and Culture 3, no. 1 (1962): 1-26.

Porter, Cheryl. "Laser Raman Spectroscopy: A Tool for Non-Destructive Pigment Analysis of Manuscripts," The Paper Conservator 16 (1992): 93-97.

Powell, Roger. "The Book of Kells, the Book of Durrow, Comments on the Vellum, the Make-Up, and Other Aspects," Scriptorium 10 (1956): 3-21.

Ramanathan, N. "Collagen: Structure of Fibrous Proteins and Polypeptides. Structure of Collagen at the Molecular Level. Stereochemical Criteria for Polypeptide and Protein Structures. The Relationship Between Shrinkage of Hide and Crystal-Liquid Transition of Collagen. Some Considerations about Biocrystallography of Collagen," Proceedings of a Symposium Sponsored by the Central Leather Research Institute, Council of Scientific and Industrial Research, Madras, India (1960): 3-78, 81-137, 444-579.

Rebrikova, N.L. and N.I. Solovyova. "Electron Microscopic and Biochemical Investigation of Parchment," ICOM Preprints of the 8th Triennial Meetng, Sydney 1987 #3: 1197-1200.

Rebrikova, N.L. and P. Ya. Muldiyarov. "Electron Microscopy of Parchment," Restaurator 5 (1983): 183-190.

Reed, Ronald. "Ancient Leathers, Parchments and Skin Products," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturen, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 102-110, 328-335.

Reed, Ronald. Ancient Skins, Parchments and Leathers, London-New York: Seminar Press, 1972.

Reed, Ronald. "The Examination of Ancient Skin Writing Materials in Ultra-Violet Light," Proceedings of the Leeds Philosophical and Literary Society, Scientific Section, 9, Part 10, 1965, pp. 257-276.

Reed, Ronald. The Nature and Making of Parchment. Leeds, England: Elmete Press, 1975.

Reed, Ronald. "On the Dating of Parchment." In Dag-Ernst Petersen, editor, Das alte Buch als Aufgabe fur Naturwissenschaft und Forschung, Bremen-Wolfenbuttel, 1977 (Wolfenbutteler Forschungen 1.) pp. 91-97.

Reed, Ronald and J.B. Poole. "A Study of Some Dead Sea Scrolls and Leather Fragments from Cave 4 at Qumran, Part II -- Chemical Examination," Proceedings of the Leeds Philosophical and Literary Society, Scientific Section, 9, Part 6 (1964): 171-182.

Reich. S., A. Katchalsky, and Oplatka. "Dynamic-Elastic Investigation of the Chemical Denaturation of Collagen Fibers," Biopolymers 6 (1968): 1159-1168.

Rembrandt: Experimental Etcher. Boston: Museum of Fine Arts, 1969.

Robinson, Andrew. Prints on Paper. Washington: National Gallery of Art, 1977.

Ryan, Kathleen. "Parchment as Faunal Record," MASCA Journal 4, no. 3 (October, 1987): 124-138.

Ryder, Michael Lawson. "The Biology and History of Parchment." In P. Rück, (editor) Pergament: (1991): 25-33.

Ryder, Michael Lawson. "Follicle Arrangement in Skin from Wild Sheep, Primitive Domestic Sheep and in Parchment," Nature 182 (1958): 781-783.

Ryder, Michael Lawson. "Follicle Remains in Some British Parchment," Nature 187 (1960): 130-132.

Ryder, Michael Lawson. "Parchment -- Its History, Manufacture and Composition," Journal of the Society of Archivists 2, no. 9 (1960-64): 391-399. Reprinted in John P. Baker, Marguerite C. Soroka, editors, Library Conservation: Preservation in Perspective, Stroudsburg, Pennsylvania, 1978, pp. 85-90.

Saxl, Hedwig. "Histology of Parchment," Technical Studies in the Field of the Fine Arts 8, no. 1 (1939): 2-9.

Saxl, Hedwig. "A Note on Parchment." In C. Singer, (editor), A History of Technology 2, Oxford, 1956, pp. 187-190.

Saxl, Hedwig. An Investigation of the Qualities, the Methods of Manufacture and the Preservation of Historic Parchment and Vellum with a View to Identifying the Animal Species Used. Master of Sc. Thesis, Leeds Department of Leather Industries, Leeds, 1954.

Science Museum London (editor). Parchment. London, 1938 (Science Library Bibliographical Series 425).

Schreiner, Peter. "Zur Pergamentherstellung im byzantinischen Osten," Codices manuscripti 9, no. 3 (1983): 122-127.

Simpson, Edward. "The Blue Koran," Paper Conservation News 69 (March 1994): 11.

Simpson, Edward. "Early Koranic Fragments," Paper Conservation News 69 (March, 1994): 6-7.

Skelton, R.A., Thomas E. Marston, and George D. Painter. The Vinland Map and the Tartar Relation. New Haven: Yale University Press, 1965, pp. 9-10.

Smith, Jane, and Victoria Bunting. "A Study of Two Nineteenth Century Deluxe Edition Prints on Parchment," Papers Published at the Nineteenth Annual Student Conference of Art Conservation Training Programs. Buffalo, New York, 1993. (In press.)

Somerville, Sam. "Parchment and Vellum." In Heather Child, editor, The Calligrapher's Handbook, London 1985, S. 59-84.

Sparrow, W.S. A Book of British Etching from Francis Barlow to Francis Seymour Haden. London: John Lane The Bodley Head Limited, 1926.

Stachelberger, H. et al. "Electrophoretic Investigations on Parchment Decay," ICOM Preprints Vol.II of the 8th Triennial Meeting, Sydney (1987): 727-729.

Tardieux, Pierre; Moussin, Marie-Hélène; Flieder, Françoise and Jacques Pochon. "Microbiologie: Altration Biologique des Parchemins," C. R. Acad. Sc. 272, Série D (March 29, 1971): 1817-1818.

Tancous, Jean J., Roddy, William T. and O'Flaherty, Fred. Skin, Hide and Leather Defects, Cincinnati, 1959.

Tanzer, Marvin L. "Cross-Linking of Collagen," Science 180, (1073): 561-566.

Thompson, Daniel Varney. The Materials and Techniques of Medieval Painting, New York: Dover, 1956.

Thompson, Daniel Varney, "Medieval Parchment-Making," The Library - Transactions of the Bibliographical Society 4, no. 16 (1935): 113-117.

Thompson, Daniel Vaney and George Heard Hamilton,"An Anonymous Fourteenth-Century Treatise 'De arte illuminandi'," The Technique of Manuscript Illumination, Yale, 1933.

Thompson, Jack. "Notes on the Manufacture of Goldbeater's Skin," AIC Book and Paper Group Annual 2 (1983): 119-122.

Tilbrooke, David R.W. "Leather and Parchment: Composition and Structure," Institute for the Conservation of Cultural Material (ICCM) Bulletin 5, no. 1 (1979): 215-240.

Ure, Andrew. A Dictionary of Arts, Manufactures and Mines. New York: D. Appleton and Company, 1873.

Ustick, W. Lee. "Parchment and Vellum," The Library - Transactions of the Bibliographical Society, Ser. 4, 16/2 (1936): 439-443.

van der Reyden, Dianne and Mary Baker. "Genuine Vegetable Parchment Paper: Effects of Accellerated Aging on Some Physical and Chemical Properties" to be published in the Materials Research Society Symposium Proceedings, Cancun (1994).

van der Reyden, Dianne, Christa Hoffmann, and Mary Baker. "Some Effects of Solvents on Transparent Papers," The Institute of Paper Conservation Conference Papers, Manchester, England (1992): 234-257.

van der Reyden, Dianne, Christa Hoffmann, Mary Baker and Marion Mecklenburg. "Modern Transparent Papers: Materials, Degradation, and the Effects of Some Conservation Treatments," Materials Research Society Symposium Proceedings, San Francisco (1992): 379-395.

van der Reyden, Dianne, Christa Hoffman, and Mary Baker. "Effects of Aging and Solvent Treatments on Some Properties of Contemporary Tracing Papers," JAIC, 1993.

Veis, Arthur, and Jerome Cohen. "Reversible Transformation of Gelatin to the Collagen Structure," Nature: 186 (1960): 720-721.

Visscher, W.P. "Trends in Vellum and Parchment Making Past and Present," The New Bookbinder 6 (1986): 41-47.

Vorst, Benjamin. "Parchment Making - Ancient and Modern," Fine Print 12, no. 4 (October, 1986): 209-211, 220-221.

Wallis, Helen, F. R. Maddison, G.D. Painter, D.B. Quinn, R.M. Perkins, G.R. Crone, A.D. Baynes-Cope, Walter C. and Lucy B. McCrone. "The Strange Case of the Vinland Map, A Symposium," Geographical Journal 140, part 2 (June 1974).

Ward, A.G., and A. Courts, eds. The Science and Technology of Gelatin. London: Academic Press, 1977.

Wehlte, Kurt. The Materials and Techniques of Painting. New York: Van Nostrand Reinhold Company, 1975.

Weiner, Stephen, Zina Kustanovich, Emanuel Gil-Av, and Wolfie Traub. "Dead Sea Scroll Parchments: Unfolding of Collagen Molecules and Racemization of Aspartic Acid," Nature 287 (1980): 820-823.

Welles, C. Bradford, Robert O. Fink, J. Frank Gilliam, Walter Bruno Henning, and Ann Perkins, editors. The Excavations at Dura-Europos, Final Report V, Part I: The Parchments and Papyri. New Haven, 1959.

Whitaker, John R., and Masao Fujimaki. "Chemical Deterioration of Proteins," ACS Symposium Series (1980): 1-99.

Wolff, Simon P., and Roger T. Dean. "Fragmentation of Proteins by Free Radicals and Its Effect on Their Susceptibility to Enzymatic Hydrolysis," Biochemical Journal 234 (1986): 399-403.

Yannas, I.V. "Cross-Linking of Gelatine by Dehydration," Nature 215 (1967): 509-510.

Young. G. Loss of Infrared Linear Dichroism in Collagen Fibers as a Measure of Deterioration in Skin and Semi-Tanned Leather Artifacts, Material Issues in Art and Archeology III 267 (1992): 859-867.

Young, G. Microscopical Hydrothermal Stability Measurements of Skin and Semi-Tanned Leather, ICOM Preprints of the 9th Triennial Meeting, International Committee of Museums, Dresden 26-31, August 1990: 626-631.

B. Treatment

Banik, Gerhard. "Conservation of Water Damaged Museum and Archival Documents," ICOM Preprints II 9th Triennial Meeting, Dresden 26-31, August, 1990: 443-446.

Belaya, I.K., "Instructions for the Softening of Parchment Manuscripts and Bookbindings," Restaurator 1 (1969-70):20-48, 49-51.

Belaya, I.K. "Selecting and Testing Adhesives for the Restoration of Skin-bindings and Parchments," Restaurator 1 (1969-1970): 221-231.

Beöthy-Kozocsa, Ildikó; Sipos-Richter, Teréz and Györgyi Szlabey. "Report on Parchment Codex Restoration Using Parchment and Cellulose Fibre Pulp," ICOM Preprints II 9th Triennial Meeting, Sydney,1987: 641-648.

Bykova, G.Z.; Ivanova, A.V. and I.P. Mokretzova. "Conservation Methods for Miniature

Paintings on Parchment: Treatment of the Paint Layer." In Conservation and Restoration of Pictorial Art, edited by Bromelle and Smith, 207-209. London: Butterworths 1978.

Calabro, Giuseppe et al. "An Evaluation of Softening Agents for Parchment," Restaurator, vol.7 (1986) pp.169-180.

Cains, Anthony. "Repair Treatments for Vellum Manuscripts," The Paper Conservator 7 (1982-1983): 15-23.

Cains, Anthony. "Repair Treatments for Vellum Manuscripts." In Guy Petherbridge, editor, Library Conservation and Archive Materials and the Graphic Arts. London-Boston, 1987, pp. 183-194.

Clarkson, Christopher. "A Conditioning Chamber for Parchment and Other Materials," The Paper Conservator 16 (1992): 27-30.

Cockerell, Sydney Morris. The Repairing of Books, London 1958 (2nd edition, 1960).

Dirda, Marian. "Synthetic Linings," Washington Conservation Guild Newsletter 8, no. 1 (January 1984).

Drayman, Terry. "The Conservation of a Petrarch Manuscript," Journal of the Walters Art Gallery 31-32 (1968-1969): 119-123.

Dreibholz, Ursula. "A Treasure of Early Islamic Manuscripts on Parchment: Significance of the Find and Its Conservation Treatment," AIC Preprints. Baltimore, Maryland, 11th Annual Meeting (May 25-29, 1983): 30-38.

Dreibholz, Ursula. "Der Fund von Sanaa: Fruhislamische Handschriften auf Pergament." In P. Rück, editor, Pergament: (1991) pp.299-314.

Dreibholz, Ursula. "Conservation of Early Koran Fragments," Paper Conservation News 69 (March 1994): 10.

Dreibholz, Ursula. "The Marburg Parchment Colloquium," The Abbey Newsletter 11, no. 8 (December 1987): 132-135.

Ellement, Peter G. "A Note on the Structure of Vellum and the Effects of Various Solvents." In Guy Petherbridge, editor, The Conservation of Library and Archive Materials and the Graphic Arts. London: Butterworths, 1987, pp.199-200.

Ellis, Margaret Holben. "Drawings on Parchment: Special Conservation Problems for Collectors," Drawing 2, no. 4 (November-December, 1980): 85-86.

Ellis, Roger. "The Principles of Archive Repair." In John P. Baker and Marguerite C. Soroka, editors, Library Conservation: Preservation in Perspective, Stroudsburg, Pennsylania, 1978, pp. 316-324.

Gairola, T.R. "Preservation of Parchment," Journal of Indian Museums 14-16 (1958-1960): 43-45.

Gimbrère, Lucie M. and Pieter F.J. Obbema. "Restaurator und Wissenschaftler," Maltechnik Restauro 4 (1985): 52-62.

Giuffrida, Barbara. "Book Conservation Workshop Manual. Part Four: The Repair of Parchment and Vellum in Manuscript Form," The New Bookbinder 3 (1983): 21-41.

Gowers, H.J., "The Conservation of Javanese Shadow Puppets", ICOM Preprints of the 4th Triennial Meeting, Venice (1975) #75/3/1: 1-7.

Jonsson, Axel. "Konservering och Restaurering av Pergament," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 358-363.

Jussoupova, M.V. "Étude des Causes de l'Apparition de la Transparence des Parchemins au Cours d'un Certain Nombre de Travaux en Restauration," in ICOM Preprints 4th Triennial Meeting, Venice (1975) (#75/15/16): 1-5.

Ketzer, Roswitha. "A Conservation Project in Kairouan," Paper Conservation News 69 (March 1994): 8-9.

Kowalik, Romuald. "Some Aspects of Microbiology of Paper and Parchment." In Dag-Ernst Petersen, editor, Das alte Buch als Aufgabe fur Naturwissenschaft und Forschung. Bremen-Wolfenbuttel, 1977 (Wolfenbutteler Forschungen 1), pp. 61-83.

Kozocsa, Ildikó. "Some Problems and Achievements in Codex Restoration in the National Széchényi Library," Conservation - Restoration of Leather and Wood: Training of Restorers Sixth International Restorer Seminar, Veszprém (13-23 July, 1987): 233-240. Budapest: UNESCO, 1987.

Landsmann, A.W., "Lubricants." in C.Calnan & B.Haines (editors) Leather: Its composition and changes with time, Northampton: The Leather Conservation Center (1991), pp.29-33.

Langwell, William Herbert, The Conservation of Books and Documents, London 1957 (repr. London 1974 and 1977).

Laursen, Per M. "'Trockene' Pergament - und Papierfaserung," Maltechnik Restauro 91, no. 4 (1985): 63-66.

Lee, Linda. "The Conservation of Pleated Illuminated Vellum Leaves in the Ashmolean Bestiary," The Paper Conservator 16 (1992): 46-49.

Lee, Mary Wood. "Removal of Active Mold Growth and Treatment of Structural Damage in Nine Erotic Indian Miniatures," AIC Preprints. Baltimore, Maryland, 11th Annual Meeting (1983): 140-149.

Lefevre, S. & C.Chahine, "Le nettoyage du parchemin", Les Documents Graphiques et Photographiques: Analyse et Conservation, Paris, Archives Nationales (1986), pp.163-183.

Logan, Judith A., and Gregory S. Young. "'A Message in a Bottle:" The Conservation of a Waterlogged Parchment Document," Journal of the International Institute for Conservation - Canadian Group 12 (1987): 28-36.

Maggen, Michael. "Conservation of the Allepo Codex," Restaurator 12 (1991): 116-130.

Marconi, Bohdan L. "Aesthetic Problems in Conservation of Art Objects on Paper and Parchment," ICOM Committee for Conservation, Proceedings of the Triennial Meeting, Paris (1969.)

Marconi, Bohdan L. "Some Tests on the Use of Wax for Fixing Flaking Paint on Illuminated Parchment," Studies in Conservation 7 (1962): 17-21.

Margotieva, Alla and Galena Bykova. "Materials and Methods of Conservation of Parchment Charters," lecture presented in Jerusalem, November 1991.

Martin, John H. "Après le Déluge... Resuscitating a Waterlogged Library." In John P. Baker and Marguerite C. Soroka, editors, Library Conservation: Preservation in Perspective, Stroudsburg, Pennsylvania: Dowden, Hutchinson & Ross, Inc., 1978, pp. 391-399.

Matthews, Charles George. "Notes on the Treatment of Parchments Damaged by Fire," The Analyst 49 (1924): 516-517.

Mecklenburg, Marion F. "The Effects of Atmospheric Moisture on the Mechanical Properties of Collagen Under Equilibrium Conditions," Conservation Analytical Laboratory, Smithsonian Institution, pp. 231-244.

Mokretsova, I.P. "Sur Quelques Particularités Technologiques et de la Restauration des deux Manuscrits Enluminés d'Europe Occidentale du XIIIe Siècle," ICOM Preprints of the 4th Triennal Meeting, Venice 1975, (#75/15/17): 1-10.

Mokretsova, I.P., Bykova, G.Z., Phinogenova,Y., and Serov,Y. "Treatment of a Greek Thirteenth Century Manuscript," ICOM Preprints of the 5th Triennial Meeting, Zagreb (1978) (#78/14/2): 1-8.

Mowery, J. Franklin. "The Conservation of a Thirteenth Century Armenian Manuscript." AIC Book and Paper Group Annual 10 (1991): 130-138.

NBS. "Preservation of the Declaration of Independence and the Constitution of the United States," NBS Circular 505. Washington, D.C.: National Bureau of Standards, 1951, pp. 1-16.

"A Note on the Conservation of Some Parchment Documents Damaged by Fire", Business Archives - The Journal of the Business Archives Council 33 (1970): 18-19.

O'Horski, Barbara. "Conservation of a Parchment Document," Art Conservation Training Programs Conference. Newark: University of Delaware, 1976, pp. 64-76.

O'Loughlin, Elissa. "The Preservation of the Declaration of Independence," National Archives Calendar of Events (July 1993).

Ozone, Judy L. "Examination and Treatment of a Pair of 18th Century Battledores," Student Papers Presented at the Art Conservation Training Programs, Eleventh Annual Conference, May 2-3, 1985, University of Delaware, Newark, pp. 79-84.

Pardle, David Bernhard. Document Repair, London, 1971 (Society of Archivists, Handbooks 1).

Parker, Tony. "Freeze-Drying of Vellum," Library Conservation News, 33, pp. 4-6.

Pedersen, Hans Peder. "Arkivvæsenets Pergamenter Bevaringsbestræbelser Gennem Tiderne," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 348-357.

Paper Conservation Catalogue. Washington: Book and Paper Group of the American Institute for Conservation of Historic and Artistic Works.

Plenderlith, H.J., and A.E.A. Werner. The Conservation of Antiquities and Works of Art. London: Oxford University Press, 1971.

Plossi, Mariagrazia Zappalà and Paolo Crisostomi. "Consolidation de la Couche Picturale des Enluminures avec Polymères Synthétiques Purs," ICOM Preprints of the 6th Triennial Meeting Ottawa (1981) (81/14/7): 1-15.

Powell, Richard. Report on the Repair and Rebinding of the Cathach Together with Further Notes and Observations. Froxfield, August 1981.

Powell, Roger. "Case History of Repair and Rebinding of an Eighth-Century Vellum Manuscript." In Philip Smith, (editor) New Directions in Bookbinding, London-New York, 1974, pp. 173-183.

Preservation of Library & Archival Materials: A Manual, Sherelyn Ogden (editor), North East Document Conservation Center, North Andover, Massachusetts, 1992.

Prosperi, Cecilia. "Il Restauro del Materiale Membranaceo," Kermes 1, no. 3 September-December, (1988): 14-17.

Quandt, Abigail, Parchment Conservation Course, Smithsonian Institution, Conservation Analytical Laboratory, Feb.1-5, 1993.

Quandt, Abigail B. "The Conservation of a 12th Century Illuminated Manuscript on Vellum," AIC Preprints 14th Annual Meeting (May 21-25, 1986): 97-113.

Ritterpusch, Ludwig. "Konservierungsprobleme mit Pergament," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 337-347.

Ritterpusch, Ludwig. "Konservierung und Restaurierung von Bucheinbänden aus Leder und Pergament," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 294-299.

Rosa, Halina. "Problems of Parchment Conservation Dealing with the Pages of Wittenbergia Bible," International Conference of Experts of Eastern European Countries on the Care and Conservation of Library Collections, Warsaw, 1987.

Scharnowell, Norbert. "Evangelien handschrift Cod. 93 in Scrinio," Restauro 1 (1991): 35-39.

Sievers, Johannes. "Fehlstellenergänzung bei Pergament durch Anfasern," Maltechnik Restauro 3 July (1979): 209ff.

Singer, Hannah. "The Conservation of Parchment Objects Using Gore-Tex Laminates," The Paper Conservator, 16 (1992): pp. 40-45.

Skordas, Gust. "The Parchment Stretcher at the Maryland Hall of Records," The American Archivist 3 (1940): 330-332.

Smith, L. Herman. "Manuscript Repair in European Archives: Part I Great Britain," The American Archivist 1, no. 2 April (1938): 1-22.

Smith, L. Herman. "Manuscript Repair in European Archives: Part II The Continent," The American Archivist 1, no. 2 April (1938): 51-77.

Stambolov, Todor. "The Conservation and Restoration of Gilt Leather," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 309-313.

Sully, D.M., "Humidification: The Reshaping of Leather, Skin and Gut Objects for Display," Conservation of Leathercraft and Related objects: Interim Symposium, ICOM Committee for Conservation (1992) pp.50-54.

Szczepanowska, Hanna. "The Conservation of 14th Century Parchment Documents and Pendant Seals," The Paper Conservator, 16 (1992): pp. 86-92.

Tanasi, M.T. et al. "Messa a punto di una metodologia relativa al restauro di pergamene dell'archivio comunale di Matelica," Le Conservazione delle carte antiche, 4, no.7-8 (1984): pp.21-26.

"Unrolling of the Dead Sea Scrolls," New Scientist 88, (1980): p. 365.

Valk-Falk, Endel. "Technique et Conservation des Reliures Gréco-Slav," ICOM Preprints of the 4th Triennal Meeting, Venice (1975): (15/1/15): 1-7.

van Soest, H.A.B. "The Restoration and Conservation of Ethnographical Leather," Konservering og Restaurering af Læder, Skind og Pergament Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturer, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kunstakademi (1980): 300-307.

Vinas Torner, V. "El polietilenglicol: tratamiento para la establizacion de libros y documentos", Centro Nacional de restauracion de libros y documentos, 2 (1979): 25-33.

Vinas, Vicente. "Parchment and Vellum Restoration: Treatment and Stabilization," Conservation Administration: Seminar on the Theoretical Aspects of the Conservation of Library and Archival Materials.R. Morrison et al. (editor). North East Document Conservation Center (pub.) North Andover, Massachusetts (1975): 108-114.

Vinas, Vicente. "The Use of Polyethylene Glycol in the Restoration of Parchment." In Guy Petherbridge, editor. Conservation of Library and Archive Materials and the Graphic Arts. London-Boston, 1987 (Proceedings of the Cambridge 1980 International Conference on Conservation), pp. 195-197.

Voronina, L.I., Nazarova, O.N., Petushkova, Yu.P. "Disinfection and Straightening of Parchment damaged by Microorganisms," in: Restaurator 4, (1980): 91-97.

Voronina, L.I.; Nazarva, O.N.; Petushkova, U.P. and N.L. Rebrikova. "Damage of Parchment and Leather Caused by Microbes," ICOM Preprints of the 6th Triennial Meeting Ottowa (1981): (81/19/3): 1-11.

Wächter, Otto. "Die De-Laminierung des karolingischen Evangeliars aus dem Essener Domschatz," Maltechnik Restauro 93, no. 2 (1987): 34-38.

Wächter, Otto. "Die Restaurierung einer Armenischen Evangelien-Handschrift (Cod. 242) aus der Bibliothek der Mechitaristen-Congregation in Wien," Österreichische Zeitschrift für Kunst und Denkmalpflege 22 (168): 43-47.

Wachter, Otto. "The restoration of the 'Vienna Dioscurides'." Studies in Conservation, vol.7 (1962): 22-26.

Wachter, Otto. "Tour of the Conservation Laboratory, National Library of Austria." In Merrily A. Smith, editor. Preservation of Library Materials, Conference held at the National Library of Austria, Vienna, April 7-10, 1986, volume 2, Munich-London-New York-Paris, 1987 (IFLA-Publications 41), pp. 92-97.

Werner, A.E. "The Conservation of Leather, Wood, Bone, Ivory, and Archival Materials," The Conservation of Cultural Property with Special Reference to Tropical Conditions, Paris: UNESCO, 1968 pp. 265-290.

Werner, A.E. "Restoration of Manuscripts and Archival Documents," Colloques Internationaux du C.N.R.S. 1974, no. 548: Les Techniques de Laboratoire dans l'Étude des Manuscrits, pp. 257-260.

Wouters, Jan and Gely Gancedo. "The Codex Eyckensis. An Illuminated Manuscript on Parchment from the 8th Century AD. Laboratory Investigation and Removal of a 30 year-old PVC Lamination," ICOM Preprints of the 9th Triennial Meeting, Dresden, Germany, August (1990):. 495-499.

Wouters, Jan, Gely Gancedo, An Peckstadt and Lieve Watteeuw. "The Conservation of Codex Eycksensis: The Evolution of the Project and the Assessment of Materials and Adhesives for the Repair of Parchment," The Paper Conservator, 16 (1992): 67-77.

Young, Pamela. "Parchment and Its Conservation," Conference of Students in Art Conservation April 10-12, 1978 Cooperstown, New York pp. 156-164.

Yusupova, M.V. "Conservation and Restoration of Manuscripts and Bindings on Parchment," Restaurator 4, no. 1 (1980): 57-69.

Yusupova, M.V. "Removal of General Soils and Pigment Spots from Parchments," ICOM Preprints of the 5th Triennial Meeting, Zagreb (1978) (78/14/11): 1-4.

Yusupova, M.V. "Removal of Transparency of Manuscripts and Documents on Parchment," ICOM Preprints of the 7th Triennial Meeting, Ottowa, (1981) (81/14/13): 1-5..

C. Storage and Display

Armstrong, Jim. "How Do You Mount an Old Wrinkled Sheepskin?" Framing, Fine Art and Wall Decor (Amersham/April/May 1977): 55-59.

Bloodworth, J.G., and M.J. Parkinson. "The Display of Parchment and Vellum," Journal of the Society of Archivists 9, no. 2 (1988): 65-58.

Clarkson, Christopher. "Preservation and Display of Single Parchment Leaves and Fragments," in Guy Petherbridge (editor) Conservation of Library and Archive Materials and the Graphic Arts, London-Boston, 1987, pp. 201-209.

Peterson, Dag-Ernst. "Notes on the Binding and Storage of Vellum-Leaved Books," in Guy Petherbridge (editor) The Conservation of Library and Archive Materials and the Graphic Arts, London: Butterworths, 1987, pp.211-217.

Pickwoad, Nicholas. "Alternative Methods of Mounting Parchment for Framing and Exhibition," The Paper Conservator, 16 (1992): 78-85.

Rekrut, A. "Parchment Mounting Methods Experiment: A Self-Study Project," unpublished. Kingston: Master of Art Conservation Program, Queen's University, 1993.

Terrell, Christopher. "A System for the Storage and Display of Manuscript Charts on Vellum," in: Ligue des bibliotheques europeennes de recherche (LIBER): Bulletin 1984, S. 20 ff.

Valentin, N., M. Lindstrom and F. Preusser. "Microbial Control by Low Oxygen and Low Relative Humidity Environment," Studies in Conservation 35 (1990): 222-230.

Woods, Maria. "The Case for Casing," Library Conservation News 14 January (1986): 1,6.

D. Environment

Androes, G.M., H.R. Gloria, and R.F. Reinisch. "Concerning the Production of Free Radicals in Proteins by Ultraviolet Light," Photochemistry and Photobiology 15 (1972): 375-393.

Anonymous. "Fungi Not Fire Damaged Aleppo Codex," Nature 355 (1988): 203.

Bowes, J.H., and A.S. Raistrick. "The Action of Heat and Moisture on Leather. Part V. Chemical Changes in Collagen and Tanned Collagen," Journal of the American Leather Chemists Association 59 (1964): 201-215.

Bowes, J.H., and A.S. Raistrick. "The Action of Heat and Moisture on Leather. Part VI. Degradation of the Collagen," Journal of the American Leather Chemists Association 62 (1967): 240-257.

Chahine, Claire, Leroy, Martine. "Effet de la Pollution Atmospherique sur le Cuir et le Parchemin," in ICOM Preprints of the 6th Triennial Meeting, Ottowa, 21-25 September (1981) (81/14/6): pp. 1-12.

Derrick, Michele, Eric Hansen, and George Rogers. "Research Proposal for the Effects of Moisture, Light and Heat on Proteinaceous Materials: Part I. Recommendation for the Display and Storage Conditions of the Dead Sea Scrolls. Part II. Factors Affecting the Degradation Kinetics of Proteinaceous Materials," Getty Conservation Institute (1988): 1-16.

Grattan, David W. "The Oxidative Degradation of Organic Materials and Its Importance in Deterioration of Artifacts," Journal of the International Institute for Conservation - Canadian Group 4, no. 1 (1980): 17-26.

Haberditzi, Anna Therese, Bauer, Friedrich, Stachelberger, Herbert, Banik Gerhard, Mairinger, Franz. "Characterization of Storage-Dependent Structural Damage in Parchment Samples by Means of SDS-PAGE." Electrophorsis '86, 5th Meeting of the International Electrophoresis Society, London, 1986, 3 S.

Kowalik, Romauld. "Decomposition of Parchment by Microorganisms," Restaurator 4, no. 3-4 (1980): 200-208.

Kowalik, Romauld. "Paper and Parchment Deteriorating Fungi Pathogenic to Man," in Dag-Ernst Petersen (editor), Das alte Buch als Aufgabe fur Naturwisenschaft und Forschung, Bremen-Wolfenbuttel 1977 (Wolfenbutteler Forschungen 1), pp. 85-90.

Lee, Sandra L. "Optimal Conditions for Long Term Storage of Native Collagens," Collagen Rel. Research vol. 3 (1983): 305-315.

Sadurska, Irena, Romuald Kowalik, Dawid Lipson, and Elzbieta Czerwinska. "Mikrobiologiczny Rozklad Materialow Uzywanych w Konserwacji, In: Annali della Scuola Speciale per Archivisti e Bibliotecari (SSAB) dell'-Universita di Roma 9(1969): 51-60 with Fig. 1-14.

E. The Marburg Parchment Colloquium (20-22 September, 1987)

GESCHICHTE UND VERWENDUNG

Rueck, Peter. "Zum Stand der hilfswissenschaftlichen Pergamentforschung,"

Ryder, Michael L. "The Biology and History of Parchment,"

Haran, Menahem. "Technological Heritage in the Preparation of Skins for Biblical Texts in Medieval Oriental Jewry,"

Endress, Gerhard. "Pergament in der Codicologie des islamisch-arabischen Mittelalters,"

di Majo, Anna; Federici, Carlo and Marco Palma. "Die Tierhautbestimmung des Pergaments der italienischen Chartae Latinae Antiquiores,"

Brown, Michelle P. "Continental Symptoms in Insular Codicology: Historical Perspectives,"

Eisenlohr, Erika. "Die Pergamente der St. Galler Urkunden: Ein praktischer Versuch zur Bestimmung von Tierhauten,"

Bischoff, Frank M. "Pergamentdicken im Evangeliar Heinrichs des Loewen und anderen Helmarshausener Evangeliaren des 12.Jahrhunderts,"

Gullick, Michael. "From Parchmenter to Scribe: Some Observations on the Mansfacture and Preparation of Medieval Parchment Based Upon a Review of the Literary Evidence,"

von Scarpatetti, Beat M. "25 Scriptoren und Maler auf 150 Folia Pergaments. Ein Schweizer Erfahrungsbericht 1986/7,"

STRUCTUR DES PERGAMENTS

Moog, Gerhard. "Haeute und Felle zur Pergamentherstellung. Eine Betrachtung histologischer Merkmale als Hilfe bei der Zuordnung von Pergamenten zum Ausgangsmaterial,"

Stachelberger, Herbert; Banik, Gerhard and Anna Haberditzl. "Naturwissenschaftliche Untersuchungen zum Pergament: Methoden und Probleme,"

Chahine, Claire. "Travaux Realisés en France dans la Domaine de Parchemin,"

Tanasi, Maria T.; Impagliazzo, Giancarlo and Daniele Ruggiero. "Une Approche Préliminaire à la Caraterisation du Parchemin,"

Reed, Ronald. "Some Thoughts on the Treatment of Parchment with Aldehydes,"

Heidemann, Eckhart. "Einige Bemerkungen ueber die Eigenschaften von Pergament aus der Sicht der Lederwirtschaft,"

RESTAURIERUNG UND KONSERVIERUNG

Waechter, Wolfgang. "Pergament: Die gegenwaertig praktizierten restauratorischen Methoden und ihre Beziehung zum Erkenntnisstand,"

Ritterpusch, Ludwig. "Pergament-Restaurierung,"

Martinovsky, Ivan. "Die neuesten tschechoslowakischen Erfahrungen auf dem Gebiet der Pergamentrestaurierung,"

Rosa, Halina and A.B. Strzelczyk. "Parchment - Report on Conservation and Scientific Methods Developed in the Laboratory of Paper and Leather Conservation at the Nicolaus Copernicus University, Torun, Poland,"

Fuchs, Robert. "Des Widerspenstigen Zaehmung [Pergament in Strucktur und Geschichte],"

Waechter, Otto. "Das Pergament als Biltraeger. Ein konservatorischer Aspekt,"

Dreibholz, Ursula. "Der Fund von Sanaa. Fruehislamische Handschriften auf Pergament,"

Lokanadam, B. "Parchment in India - Some Observations,"

Schmitzer, Werner. "Pergament: Das Material fuer Schattenspielfiguren, ihre Herstellung und ihre Restaurierung,"

PERGAMENTHERSTELLUNG HEUTE

Visscher, J. "Parchment: Properties and Varieties Manufactured at William Cowley Parchment Works, Newport Pagnell, Great Britain,"

Wildbrett, Manfred and Edith Wildbrett. "Hautpergament - ein Naturprodukt von erlesener Schoenheit,"

Vorst, Benjamin. "Mysterious Vellum,"

de Groot, Zeger H. "Die Herstellung von Goldschlaegerhaut, transparentem und gespaltenem Pergament,"

Esteves, Lilia M de A.A. and Luisa M.P.P. Alves. "Note sur l'Étude du Parchemin au Portugal: Sa Fabrication,"

Ameneiro, Rony. "From Banjos to Parchment,"

IKONOGRAPHIE UND BIBLIOGRAPHIE

Janzen, Stephan. "Bilder zur Pergamentherstellung,"

Institut fuer Historische Hilswissenschaften and Stephen Janzen. "Pergamentbibliographie,"

Verzeichnis Heutiger Pergamenthersteller.

Personal Correspondence

McIntosh Patrick, A. 1993. Personal correspondence.

Morrow, G. 1993. Personal communication.

Young, G. 1993. Personal communication.

Addendum to Bibliography

A. History, Technology and Science

Chahine, Claire, Christine Rottier and Dominique Rouy. "Effets des Adhesifs sur les Proprietes Mecaniques du Parchemin," Sauvegarde et Conservation des Photographies, Dessins, Imprimes et Manuscrits, Actes des Journees Internationales d'Etudes de l'ARSAG, Paris, 30 Septembre au 4 Octobre 1991, pp.139-146.

di Majo, Anna, Carlo Federici and Marco Palma. "Indagine sulla Pergamena Insulare (Secoli VII-XVI)," Scriptorium 62, no.2 (1988): 131-139 and Plates 9-14.

di Majo, Anna, Carlo Federici and Marco Palma. "La Pergamena dei Codici Altomedievali Italiani. Indagine sulle Specie Animali Utilizzate," Scriptorium 39, no.1 (1985): 3-12.

Down, Jane L., Maureen A. MacDonald, Jean Tetreault and R. Scott Williams. Adhesive Testing at theCanadian Conservation Institute - An Evaluation of Selected Poly(vinyl acetate) and Acrylic Adhesives, Environment and Deterioration Report No. 1603. Ottowa, Canada: Canadian Conservation Institute, 1992.

Feller, Robert L., Nathan Stowlow and Elizabeth H. Jones. On Picture Varnishes and their Solvents. Cleveland: The Press of Case Western Reserve University, 1971.

Gallo, Fausta and Alicja Strzelczyk. "Indagine Preliminare sulle Alterazioni Microbiche della Pergamena," Bollettino dell'Istituto di Patologia del Libro 30, nos.1-2 (1971): 71-87.

Gettens, Rutherford and George Stout. Painting Materials. New York: Dover Publications, date?

Godet, Eric. "La Preparation du Parchemin en Ethiopie," Abbay, no.11 (1980-1982): 203-208 and Figs. 1-4.

Greene, Virginia. "'Accessories of Holiness': Defining Jewish Sacred Objects," Journal of the American Institute for Conservation 31, no.1 (1992): 31-39.

Haines, Betty M. "Ground Substance: Its Relationship to the Tannning Process," Leather Conservation News 3, no.2 (1987): 9.

Haines, Betty M. The Fibre Structure of Leather. Northampton, England: The Leather Conservation Centre, 1981.

Hallebeek, P.B. "Notes Concerning the Condition of Parchment," ICOM Arbeitsgruppe, Leathercraft and Related Objects, International Leather- and Parchmentsymposium, 8-12 May, 1989: 85-93.

Keck, Sheldon. "Mechanical Alteration of the Paint Film," Studies in Conservation 14, no.1 (1969): 9-30.

Oltrogge, Doris and Robert Fuchs. "Naturwissenschaftliche Untersuchungen an HistorischemPergament," ICOM Arbeitsgruppe, Leathercraft and Related Objects, International Leather-and Parchmentsymposium, 8-12 May, 1989: 104-115.

Polacheck, I., I.F. Salkin, D. Schenhav, L. Ofer, M. Maggen and J.H. Haines, "Damage to an Ancient Parchment Document by Aspergillus," Mycopathologia 106 (1989): 89-93.

Porck, Henk J. "Identification of Parchment using Isoelectric Focusing," ICOM Arbeitsgruppe, Leathercraft and Related Objects, International Leather and Parchment Symposium. 8-12 May, 1989: 60-64.

Rose, C.L. and D.W. Von Endt, editors. Protein Chemisty for Conservators Course sponsored by the Objects Specialty Group, Los Angeles, California, May 15, 1984. Washington, D.C.: The American Institute for Conservation, 1984.

Van Oosten, Th.B., "Characterisation of Parchments and Animal Glues from Different Kinds of Animals by Thin Layer Isoelectric Focusing," Leather Conservation News 5, no.2 (1989): 1-6.

Watrous, James. The Craft of Old-Master Drawings. Madison, Wisconsin: The University of Wisconsin Press, 1957.

B. Treatment

Ballago, Mrs. Laszlo and Maria Czigler. "The Restoration/Conservation of an Outsize Eleventh Century Parchment Gradual." In Beatrix Kastaly, editor, Papers of the Conference on Book and Paper Conservation held in Budapest 4-7 September 1990. Budapest: Technical Association of Paper and Printing Industry and the National Szechenyi Library, 1992, pp.306-308.

Bansa, Helmut. "Polyglykol fur Pergament," Maltechnik (1982): 274-277.

Bansa, Helmut. "Restaurierung von Buchmalerei," Maltechnik Restauro 2 (1980): 93-95.

Bervas, Marianne. "La Restauration de Miniatures sur Parchemin," Sauvegarde et Conservation des Photographies, Dessins, Imprimes et Manuscripts, Actes des Journees Internationales d'Etudes de l'ARSAG, Paris, 30 Septembre au 4 Octobre 1991, pp.152-156.

Burns, Thea and Margaret Bignell, "The Conservation of the Royal Charter and Great Seal of Queen's University," The Paper Conservator 17 (1993): 5-12.

Bykova, G.Z., "Medieval Painting on Parchment: Technique, Preservation and Restoration," Restaurator 14, no.3 (1993): 188-197.

Cains, Anthony. "A Facing Method for Leather, Paper and Membrane." In Sheila Fairbrass, editor, Conference Papers Manchester 1992, The Institute of Paper Conservation, 1992, pp. 153-157.

Cockerell, Douglas. "Condition, Repair and Binding of the Manuscript." In H.J.M. Milne and T.C.Skeat, Scribes and Correctors of the Codex Siniaticus. London: The British Museum, 1939, pp.70-86.

Dignard, Carole. "Tear Repair of Skins with Minimal Access to their Backs: The Treatment of a Kayak," Leather Conservation News 7, no.2 (1992): 1-8.

Ellis, Margaret Holben. The Care of Prints and Drawings. Nashville, Tennessee: The American Association of State and Local History, 1987.

Farkas, Csilla. "The Problems of Conserving/Restoring a Corvinus Manuscript Covered in Velvet." In Beatrix Kastaly, editor, Papers of the Conference on Book and Paper Conservation held in Budapest 4-7 September 1990. Budapest: Technical Association of Paper and Printing Industry and the National Szechenyi Library (1992), pp. 164-173.

Fogle, Sonja, Toby Raphael and Katherine Singley, editors. Recent Advances in Leather Conservation. Preceedings of a Refresher Course sponsored by FAIC, June 1984, Harpers Ferry, West Virgina. Washington, D.C.: The American Institute for Conservation, 1985.

Forde, Helen. Doomsday Preserved. London, England: Public Record Office, 1986.

Fuchs, Robert. "Blaufarbmittel in illuminierten Handschriften und Drucken - ihre zerstorende Wirkungen und restauratorische Konsequenzen." In K. Jonas Palm and Mogens S. Koch, editors, Preprints for the 7th International Congress of Restorers of Graphic Art, 26-30 August 1991, Uppsala, Sweden, pp.1-9.

Fuchs, Robert, Renate van Issem, Doris Oltrogge and Gertrud Schenck. "Glas oder Kunstoff? Zur Konservierung der 'Quedlinburger Itala-Fragmente' in der Deutschen Staatsbibliothek, Berlin (DDR)," Restauro 4 (1988): 285-291.

Fuchs, Robert. "Nolite Manuscripta Cruciare sed Conservate Potis.

Uberlegungen sur Konservierung Mittelalterlicher Buchmalerei," Maltechnik : 39-49.

Fuchs, Dr. Robert. "Neue Untersuchungen zur Konservierung von mittelalterlicher Buchmalerei." In Beatrix Kastaly, editor, Papers of the Conference on Book and Paper Conservation held in Budapest 4-7 September 1990, Budapest: Technical Association of Paper and Printing Industry and the National Szechenyi Library (1992), pp. 295-301.

Goddard, Patricia. "Humidity Chambers and their Application to the Treatment of Deformations in Fabric-Supported Paintings," The Conservator, no.13 (1989): 21-24.

Giovannini, Andrea. "Archeologie et Restauration des Livres et des Documents d'Archives Medievaux," Gazette du Livre Medieval 17 (Autumn 1990): 7-19.

Hamburg, Doris. "The Washington Haggadah, A Conservator's Perspective." In Myron M. Weinstein, editor, The Washington Haggadah: Commentary, Washington, D.C.: Library of Congress, 1991, pp.171-195.

Johnson, Rebecca. "Conservation of a Patent Document on Parchment and an Exploration of Tensioning Techniques for Flattening Parchment," in Papers Presented at the Sixteenth Annual Art Conservation Training Programs Conference, April 26-28, 1990, University of Delaware/Winterthur Museum, pp.21-31.

Jonsson, Axel. "Konservering och Restaurering av Pergament," Konservering og Restaurering af Laeder, Skind og Pergament, Kompendium fra Nordisk Videreuddannelseskursus, 3-14 April 1978, Kulturen, Lund, Sverige. Copenhagen: Konservatorskolen Det Kongelige Danske Kumsrakademi (1980): 358-363.

Kaminitz, Mairian and Judith Levison. "The Conservaion of Ethnographic Skin Objects at the American Museum of Natural History," Leather Conservation News 5, no.1 (1988): 1-7.

Michalski, Stefan and Carole Dignard. "A New Method of Consolidating Powdery Matte Paint: The Ultrasonic Mister," unpublished paper.

Mora, Paolo. "Il Restauro delle Miniature," Bollettino dell'-Istituto per la Patologia dell'Libro 27 (1968):113-115.

Munn, Jesse. "Treatment Techniques for the Vellum Covered Furniture of Carlo Bugatti," The Book and Paper Annual 8 (1989): 27-38.

Parker, A.E., "Freeze-drying of Vellum Archival Materials," Journal of the Society of Archivists 14, no.2 (1993): 175-188.

Pederson, Hans Peder. "(title unknown)", Papers of the 18th International Congress of Paper Historians, Copenhagen, Denmark, 11-14 August 1986, IPH Yearbook 6 (1986).

Petukhova, Tatyana. "Potential Applications of Isinglass Adhesive for Paper Conservation," The Book and Paper Group Annual 8 (1989): 58-61.

Petukhova, Tatyana and Stephen D. Bonadies, "Sturgeon Glue for Painting Consolidation in Russia," Journal of the American Institute for Conservation 32, no.1 (1993): 23-31.

Powell, Roger. "The Lichfield St. Chad's Gospels: Repair and Rebinding, 1961-1962," The Library, Ser. 5, 20, no.4 (1965): 259-265, Figs.1-11 and Plates I-IX. Powell, Roger. Report on the Repair and Rebinding of the Book of Kells. Froxfield, 1955.

Purinton, Nancy and Susan Filter. "Gore-Tex: An Introduction to the Materials and Treatments," The Book and Paper Annual 11 (1992): 141-155.

Quandt, Abigail B. "The Butler Hours: The Conservation and Rebinding of a Fourteenth Century English Book of Hours." In Sheila Fairbrass, editor, Conference Papers Manchester 1992, The Institute of Paper Conservation, 1992, pp. 171-177.

Quandt, Abigail B. "The Documentation and Treatment of a Late 13th Century Copy of Isidore of Seville's Etymologies," The Book and Paper Annual 10 (1991): 164-195.

Rouy, Dominique and Claire Chahine. "Elimination des Taches sur le Parchemin a l'aide de Peroxyde d'Hydrogene: Premiers Resultats," ICOM Committee for Conservation, Preprints for 10th Triennial Meeting, Washington, D.C. 22-27 August 1993: 474-478.

Shelley, Marjorie. "Old Master Drawings: An Approach to Conservation," The Book and Paper Annual 8 (1989): 62-66.

Szlabey, Gyorgyi. "Restoration of Corvina Cod. Lat.3." In Beatrix Kastaly, editor, Papers of the Conference on Book and Paper Conservation held in Budapest 4-7 September 1990, Budapest: Technical Association of Paper and Printing Industry and the National Szechenyi Library (1992), pp.576-599.

Turner, Nancy, "The Conservation of Medieval Manuscript Illuminations and the Question of Compensation, WAAC Newsletter 16, no.1 (January 1994): 21-22.

Van Soest, H.A.B. "Researching the Conservation and Restoration of

Parchment," ICOM Arbeitsgruppe, Leathercraft and Related Objects, International Leather- and Parchmentsymposium, 8-12 May, 1989: 94-103.

Vuori, Jan, "A Possible Adhesive for Native Tanned Skin," Leather Conservation News 2, no.1 (1985):6.

Wachter, Otto. "Diagnosis and Therapy in Parchment and Miniature

Restoration," originally published in Restaurator 5, nos. 1&2 (1981-82): 135-150. English translation by Nancy A. Miller, edited by Jack C. Thompson, The Caber Press, 1987.

Wachter, Otto. "Die De-Laminierung des Karolingischen Evangeliars aus dem Essener Domschatz,"Maltechnik 93, no.2 (1987): 34-38.

Wachter, Otto. Restaurierung und Erhaltung von Buchern, Archivalien und Graphiken. Vienna, Austria: Hermann Bohlaus Nachf, 1982.

Weidner, Marilyn Kemp. "Treatment of Water Sensitive and Friable Media using Suction and Ultrasonic Mist, " The Book and Paper Annual 12 (1993): 75-84. Weidner, Marilyn Kemp. "Water Treatments and their Uses within a Moisture Chamber on the Suction Table," AIC Preprints, Washington, D.C. (May 1985): 127-140.

Welsh, Elizabeth C. "A Consolidation Treatment for Powdery Matte Paint," AIC Preprints. San Francisco, 8th Annual Meeting (1980): 141-150.

Wolbers, Richard C., Nanette T. Sterman and Chris Stavroudis. Notes for Workshop on New Methods in the Cleaning of Paintings. Los Angeles, California: The Getty Conservation Insitute, 1990.

Wouters, Jan, Gely Gancedo, An Peckstadt and Lieve Watteeuw, "Parchment Leafcasting with Dermal Tissue Preparations," ICOM Committee for Conservation, Preprints for 10th Triennial Meeting,Washington, D.C. 22-27 August 1993: 524-528.

Wo_niak, Maria. "Zur Restaurierung eines Illuminierten Pergamentmanuskriptes aus dem 18. Jahrhundert," Restauro 4 (1990): 295-301.

C. Storage and Display

Bloodworth, J.G. and M.J. Parkinson. "The Display of Parchment and Vellum," Journal of the Society of Archivists 9, no.2 (1988): 65-68.

Ciccarini, Letizia Montalbano. "Il Sistema Giapponese dei 'Falsi Margini.' Applicazioni Tradizionali e Nuove Proposte di Intervento," Kermes 5, no.14 (1992): 18-26.

Glaser, Mary Todd, Steven Weintraub and Ellen Marlatt. "The Bill of Rights Goes to Spain," The Book and Paper Annual 12 (1993): 20-23.

D. Environment

Hansen, Eric F., Steve N. Lee and Harry Sobel, "The Effects of Relative Humidity on some Physical Properties of Modern Vellum: Implications for the Optimum Relative Humidity for the Display and Storage of Parchment," Journal of the American Institute for Conservation 31, no.3 (1992): 325-342.

Florian, Mary-Lou E. "Conidial Fungi (Mould) Activity on Artifact Materials - A New Look at Prevention, Control and Eradication," ICOM Committee for Conservation, Preprints of the 10th Triennial Meeting, Washington, D.C. 22-27 August 1993: 868-874.

Schilling, Michael R. and William S. Ginell, "The Effects of Relative Humidity Changes on Dead Sea Scrolls Parchment Samples," ICOM Committee for Conservation, Preprints of the 10th Triennial Meeting, Washington, D.C. 22-27 August, 1993: 50-56.

18.6 Special Considerations

18.6.1. Distinguishing True Parchment from Modern Parchment and Vellum Papers (Dianne van der Reyden)

Parchment and vellum papers are generic names for two of four types of tracing papers. Tracing papers are made by either 1) processing the paper fibers by overbeating the fiber raw stock pulp slurry, which breaks down fiber structure and reduces porosity, thereby eliminating light scattering air/fiber interfaces (as with natural tracing papers), and/or 2)processing the formed paper sheet to fill voids, pores, and interfaces with material having a refractive index similar to paper fibers, by either immersion of the paper sheet in acid (used for genuine parchment paper), calendaring of the sheet (used for imitation parchment paper) and/or applying a transparentizer (coating and/or impregnating agents) to the sheet (used for vellum or prepared tracing paper).

Natural tracing paper is usually made from highly overbeaten chemical wood pulp that results in relatively flat and easily fibrillated fibers having good conformation. The fibers are processed by overbeating in a large volume of water (c.6% fiber content) at a high temperature (c.80 degrees centigrade) in order to soften the fibers and increase fibrillation and bonding. This fiber processing, compounded by machine calendaring, results in the near total collapse of interfiber voids, making the paper highly translucent, with a relatively matte surface.

Parchment paper, also called vegetable parchment, is a generic term used for either genuine parchment paper or imitation parchment paper, which are made in totally different ways. **Genuine parchment paper**, usually made of slightly beaten chemical wood pulp, is transparentized by momentary immersion of the paper sheet in baths of diminishing strengths of acid (such as sulfuric acid for thin paper or zinc chloride for thicker paper), which swell and partially disperse wood fibers, leaching out short chain beta-cellulose and gamma cellulose, forming an amyloid gel. Translucency is achieved when washing and neutralization reconstitutes, solidifies, and reprecipitates the cellulose and gel, so that during drying, the dispersed short chain polysaccharides form membranes which are deposited on and around the remaining fiber structure, effectively dispelling air within the interfiber voids. This process bonds the fibers into a grease and solvent resistant paper having high initial wet strength, often used for off-set lithography and silk-screen printing.

Imitation parchment paper, such as glassine, is made of chemical wood pulp that undergoes prolonged beating (20-30% fiber content in water) to fibrillate and partially "gelatinize" the fibers. Translucency is enhanced when the sheet, dampened to 10-30% moisture content, is supercalendared under high pressure (ca. 2000-3000 lbs/linear inch) and heat (surface roll temperature of 180-200 degrees C), generating steam that dries the paper to a 5-7% moisture content and expels air, causing further collapse of the paper structure. Supercalendaring imitation parchment paper causes the top side to become highly glazed as fines and fillers are molded smooth, while fibers on the underside of the sheet become flattened.

Vellum papers, prepared tracing and recently developed "self-healing" tracing papers are usually made from slightly beaten cotton fibers. The low fibrillation potential of cotton fibers, combined with their twisted structure, prevents close conformation of the

fibers, resulting in the scatter of light at the fiber/air interface around voids or pores. To achieve translucency, voids must be filled by impregnation and/or coating with transparentizing agents having a refractive index similar to cellulose. Resins are added either to the fiber pulp slurry (wet-end additives) to improve wet and dry strength (by preventing water from penetrating and breaking hydrogen bonds) and stiffness (by increasing adhesion between fibers), or to the surface of the formed paper sheet to improve water and scuff resistance. Transparentizers used in the past also include oils and waxes.

Tracing papers may react differently than parchment skin to aqueous treatments, which may cause expansion and opacity of the papers as compared with shrinkage and translucency in parchment skin. Solvents may cause an increase in opacity if they affect the coating of vellum papers. Translucent papers can not be flattened by tensioning as can skin (which would cause paper to split), but rather they should be dried under some form of contact pressure. Humidity pack humidification systems should be avoided as they may cause softening and distortion of coatings on papers.

The above information has been extracted from: van der Reyden, D., C. Hofmann, and M. Baker, "Effects of Aging and Solvent Treatments on Some Properties of Contemporary Tracing Papers," JAIC, 33, 1993, 177-207 and van der Reyden and M.Baker, Genuine Vegetable Parchment Paper: Effects of Accellerated Aging on Some Physical and Chemical Properties, to be published in the proceedings from the Materials Research Group Symposium, Cancun, May 1994.

18.6.2. Fumigation (Walter Newman)

Any fumigation technique suspected of having deleterious effects on paper should be suspected of also being unsafe for parchment. The increased sensitivity of parchment to heat may make it even less suitable than paper for exposure to processes where heat is involved, such as thymol chambers and microwave radiation. Since the growth of most fungi is favored by an acidic environment, parchment, which is naturally alkaline, is less subject to fungal attack than paper (see Szczepanowska 1992). As with paper, there is no substitute for good housekeeping in combating fungi, insects, bacteria and other forms of biological attack. Every fumigation procedure is only a temporary measure at best, and in fact may render an artifact vulnerable to even more vigorous biological attack when it is returned to an inhospitable environment. Since parchment responds so readily to humidity fluctuations, and since all infestations are promoted by high humidity levels, there is added incentive for controlling relative humidity levels where parchment is stored.

A report from the Center for Occupational Hazards in 1983 warned that "Routine fumigation should be avoided and fumigants should be used when all other control measures have failed." If it is decided to go ahead with fumigation, it should be remembered that parchment is an organic material, so any fumigant which affects organic materials may damage the parchment irreversibly. An example reported by Szczepanowska is ethylene oxide, which may result in loss of adhesion of gum arabic and animal glues and can cause a cross-linking reaction with proteins. Organic materials commonly found in parchment artifacts which could also be affected by fumigation include parchment sizes, fish glue, and gelatin. Metals for gilding, pigments, and binders could also be at risk. Fuchs reports severe damage to pigments, especially vegetable dyes, in experiments exposing colors produced according to

medieval recipes to formalin and ethylene oxide. Some colors shifted in hue, some changed completely (e.g. from red to green), and some sank into the parchment supports and penetrated to the reverse. (see Fuchs et al. 1988)

18.6.3. Relative Humidity Levels for the Display and Storage of Parchment: A Consideration of Levels Below 50% (Eric Hansen)

The most often encountered recommendations for the optimum relative humidity (RH) for the storage of parchment are usually around 50%. Investigations were carried out at the Getty Conservation Institute from 1988 to 1992 to determine the basis for this recommendation; and, what further information needed to be gathered to confirm or augment this recommendation (Hansen et al 1992). The effect of relative humidity on the biodeterioration of parchment was also studied (Valentin et al 1990). A further investigation was conducted specifically for the effect of relative humidity on the Dead Sea Scrolls (Schilling and Ginell 1993).

Conclusions based upon a survey of the previous conservation literature were: 1) 50 % RH was necessary to maintain a pliable or manipulable state of parchment; and 2) that a relative humidity below 70 % was necessary to inhibit noticeable fungal or microbial growth. One noticeable exception was the preservation conditions suggested by the National Bureau of Standards for the Charters of Freedom of the United States (the Constitution and Declaration of Independence), which are maintained in a helium atmosphere humidified to 25 % RH (NBS 1951).

An extensive review of the biochemical literature was conducted to determine the degradation rates and physical properties of collagen, which constitutes 95% of defatted, dehaired skin. It had been shown since the early 1940's that collagen requires a certain amount of water to maintain its molecular stability, which is present at relative humidities above 25% (Kozlov and Budygnia 1982). Thus a lower limit of relative humidity for the preservation conditions of objects containing intact collagen is 25%. This was the reasoning that was used by the NBS to set the conditions for the Charters of Freedom of the United States. Further data from the leather industry (Bowes and Kaistrick 1964, 1967) indicated that relative humidities above 40% increased the rate of the conversion of collagen to gelatin (the course of denaturation for the protein collagen).

Further testing (Hansen et al 1993) was done to determine the effects of maintaining different relative humidities on the mechanical properties of modern, intact parchment at different relative humidities. Standard samples of calfskin parchment were subjected to (1) tensile fracture, and (2) measurement of the force that developed when restrained samples were subjected to step decreases in relative humidity in the region between 60% and 11%. The results indicate that, although no particular level of relative humidity can be excluded in general from consideration as a storage or display condition on the basis of tensile fracture testing data alone, at 11% RH there is a decrease in both the ability to elongate and in the tensile strength. It was further demonstrated that below 25% RH large stresses could develop in restrained samples.

Valentin and her co-workers (1990) demonstrated that biodeterioration, for both aerobic and anerobic micro-organisms common to parchment deterioration, resulting from the growth of micro-organisms occurred beginning at 40% RH and increased with higher levels of relative humidity. Hansen and co-workers (1992), on

consideration of the physical chemistry and chemical reactivity of collagen, the effect of RH on physical properties, and the results of the biodeterioration study, suggested that a relative humidity below 40% and above 25% should be optimum for storage or display if preservation of the collagen was the primary consideration. 30% was suggested as an optimum level, permitting a cyclic variation of ± 5% with minimal effects of swelling and shrinkage.

These considerations have been the subject of some debate and concern among librarians and archivists. Of particular concern are: 1)when these conditions might be favored as opposed to higher relative humidities around 50%; 2)what problems might be encountered with parchment in varied states of age and deterioration; and 3)what problems might be encountered with the composite nature of documents and illuminated manuscripts, particularly in regard to inks and colorants. Burns (1993) summarized a discussion held at the "Conservation of Parchment" course and workshop (held at the Conservation Analytical Laboratory, Smithsonian Institution, February 1-5, 1992), which helps clarify these issues.

Burns (1993) stressed that the recommendations for lower relative humidities were not a blanket recommendation, but an attempt to define "the lowest amount of atmospheric moisture (above 25% RH) that will allow for mechanical requirements...other composite elements, and aesthetic requirements" (Hanens, et al., 1993). In the discussion, it was recognized that "rather than implementing changes based upon them, archivists might use the findings to reflect upon a situation that is not as straightforward as they perhaps had thought...Those charged with the care of collections may have other aims, such as handling and aesthetic considerations. Conservators must evaluate the specific context of individual collections - the type of parchment, historical and geographic origins, processing and finishing variables, subsequent use, storage history, present needs, media -- and assess the feasibility and practicality of the recommendations of Hansen and his co-workers."

It can be seen that much subsequent research and work needs to be done to determine adequate relative humidity conditions for the full range of types of parchment materials in archival collections. For example, Schilling and Ginell (1993) investigated the dimensional changes in Dead Sea Scroll samples and laboratory degraded parchment (partial conversion to gelatin), and confirmed the large changes associated with levels below 25% RH for historic samples. A suggested immediate concern for future research would be investigations of the effect of different relative humidities on the stability of inks on documents or paint in illuminated manuscripts.

18.6.4. Case History: Conservation of Early Koran Fragments (Ursula Dreibholz, edited by Walter Newman)

During the restoration of the west wall of the Great Mosque in Sanaa, in 1972, over 40,000 manuscript leaves and fragments from the first to the fifth Higri (700-1200 A.D.) were discovered between the outer roof and inner ceiling of the mosque. This was most likely a place to discard Korans which could not be used any more because they were damaged, but which could not be simply thrown away because of their sacred nature. As soon as the importance of the find was realized, the question of preservation arose. In 1980 an agreement was reached between Germany and Yemen to set up a special project, sponsored by the German Foreign Ministry, to catalog and conserve the artifacts.

Fragments from almost 1000 different volumes of the Koran have been distinguished but not one of these volumes is complete. Leaves range in size from 50 x 80mm to 400 x 450mm. They date as early as the seventh century A.D., and include printed texts as late as the 19th century. Most of the manuscript is in brown or black ink and color has been used for the dots of the vocalization marks and other pronunciation signs as well as occasional decorations such as verse stops and sura headings. The number of fragments written on parchment has been estimated at twelve to fifteen thousand. There is also a large but uncertain number of fragments written on paper. The parchment manuscripts have been given priority so far, as they include examples which are more significant to early Koranic paleography.

At the time of their discovery the condition of the objects varied from very good to almost totally destroyed. It was immediately obvious that the material had been a source of food for rodents and insects. However, much of this damage may have occurred prior to storage in the roof. Rain from the undetected leaking roof had mixed with centuries of dust to form encrustations upon a great many of the manuscripts, some of which resembled bricks. The water had caused inks to bleed or even disappear completely; there were severe cases of parchment shrinkage and in the worst examples the parchment skin had irreparably deteriorated. Still, despite localized damage from rain water, many of the parchment leaves were relatively well preserved, thanks to the dry climate of the area. Relative humidity averages between 25-35% most of the year, and only goes up to 50-60% during the two rainy seasons. Although the leaves are very dry, stiff, and brittle, they are preserved and can be successfully relaxed in the humidity chamber. Other damage took the form of heavy pleating and creasing, tears, and deliberate mutilation where areas of the leaves had been cut out.

The immediate aim of the initial conservation treatment was to consolidate the material so that it could be examined. This mainly involved gentle relaxation and cleaning of the items. Tears were only repaired when it was deemed that the item could not otherwise be safely handled. Extremely fragile leaves were placed in polyester film sleeves which were open on two sides to assure air flow and easy retrieval. Although the treatment applied to most of the items was simple, each item was individually assessed and treated according to its particular needs.

The previous conservator had reportedly used urea for treating the parchment. She did not use a humidification chamber at all, but applied urea solution liberally to the parchments and then pressed them while still wet. Consequently, some of the leaves have a shiny, translucent, and alien appearance.

Since a purpose-built conditioning chamber was not available, a much simpler but effective device was employed. This was constructed by placing a shallow tray of water at room temperature into a larger container. Nylon netting, with its edges glued between strips of strong plastic to give support to the parchment leaves, was suspended above the tray. The nets were in turn supported by frames cut out of sheets of foam rubber, which allowed sufficient space between the nets to accommodate the deformed parchment leaves. The uppermost net was then covered by a layer of moist blotting paper, while a wooden board with a thinner foam rubber glued inside it closed the chamber tight enough to create an appropriately humid atmospher. The humidity level could be varied by leaving the cover slightly open,or by not using moist blotting paper, or by leaving the pages in the chamber for longer or shorter periods of time.

After an overnight stay in the chamber the leaves were easily unfolded and unrolled, and pages stuck together were separated with care.

Dirt was then cleaned off with a cotton ball moistened with a solution of four parts ethanol and one part water. After several tests this was found to be the most efficient mixture for this purpose. When used carefully it removed dust and dirt effectively but did not affect the inks or pigments. It also softened fly spots and encrustations to the point where they could be removed easily with a scalpel. The alcohol seemed to help distribute the moisture evenly throughout the parchment, while at the same time preventing it from becoming too wet. The hair side was always dampened first because it does not absorb moisture as readily as the flesh side, and this helps prevent the edges from curling. During local dampening it could be observed that parchment which was exposed to excessive moisture or to water at an earlier time (which was clearly indicated by increased decomposition, shrinkage, or discoloration) was more hygroscopic and reactive to moisture even if it had been dry for a long time.

Next came what proved to be the most difficult operation, that of tensioning the fragments in order to ease out creases, stretch shrunken parts, and smooth out curled edges. The irregular shapes of the fragments, and their fragile nature, meant that conventional methods of "pinning out" could not be used. The following technique was employed instead. The humidified and relaxed item was placed between sheets of waxed paper or silicon paper, weights were gradually placed over the object section by section, and the parchment was allowed to dry slowly. Some sections had to be manually stretched or manipulated. Sometimes the procedure had to be repeated several times, although generally once was enough. As the item dried, the parchment was checked about every ten minutes, especially to make sure that no edges were folded over, which would cause permanent damage under pressure, and heavier weights were placed on the item. When almost dry, the parchment was lightly sprayed with the ethanol/water solution, placed between sheets of waxed or silicon paper, and placed in a press with very light pressure. After a day had gone by, when there was no longer a risk of paper fibers sticking to the damp ink or of the ink offsetting, the waxed paper was replaced with blotting paper. This process was monitored over a period of a week or even until the moisture content of the parchment was stable and there were no longer signs of the parchment tending to move, and then the fragments were left in the press between blotters for another three weeks or even longer. Following this treatment they had usually regained sufficient flexibility and stability to have their textual content examined.

The main concern over the last few years has been the permanent storage of the collection. The huge task of cataloging the material relies on quick retrieval, so the system has to be flexible enough to accommodate newly cataloged items which are to be reunited with other leaves from the same codex. As mentioned above, extremely fragile leaves are placed in polyester film sleeves open on two sides. All the leaves are placed in flat folders which are lined with thin acid-free board. A sheet of polyester film is attached to this lining and then folded back over the object. In this way when the upper part of the folder is lifted one can easily see the object, while it is still protected by the sheet of polyester film and cannot fall out or curl. For larger and thicker parts of volumes a sheet of polyester film is attached to the inside of a wrapper of acid-free board. The polyester film covers the top leaf and permits instant visibility when the board wrapper is opened. A window is also cut in the top board for

visibility.The two boards confine the leaves like the covers of a book. They are tied together with linen tape, and the unit is stored in a drop-spine box. The boxes are stored horizontally, in the tradition of the Islamic book, in specially fitted cabinets.There is a folder for every signature, and the labels for over-sized or bulky objects which are too big to fit into the regular folders are color-coded so that one sees at a glance if the item is kept in a box or in the cabinet for oversized volumes.

The fragments are too weak to be resewn, and since the volumes are incomplete there is always the possibility that other leaves will come to light from among the unrestored material. So all consideration of rebinding, as well as of mending tears and filling in lost areas, has been postponed until the stabilization of the collection is complete and a more comprehensive program of priorities has been established. The conservation and storage facilities are installed in the Dar al-Makhutat, the manuscript library, which is across from the Great Mosque in the old city of Sanaa, where the fragments were found.

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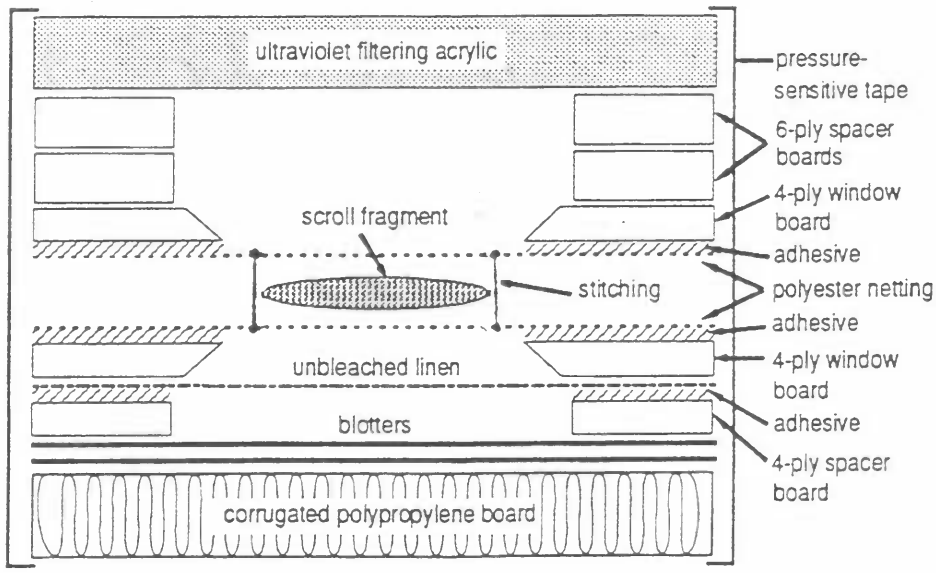
18.6.5. Housing of Dead Sea Scroll Fragments for Exhibition Tour in the United States (1993-1994) (Doris Hamburg)

The twelve Dead Sea Scroll fragments chosen for exhibition in the United States (1993-1994- three venues) are quite variable in terms of visual appearance and condition, though all are considered fragile. Some are very dark; others are quite light in color. In some cases there has been delamination on the top layer and tenting along cracks. Insect and/or mold is apparent on some. The thickness varies as well. Brittleness is a characteristic shared by most. Some scrolls were previously lined with lens tissue and a resin adhesive. All have breaks, losses, and staining. Many have undulations, and are not flat. In general the carbon ink appears well adhered to the support. The skin materials of the Dead Sea Scrolls are thought to come primarily from sheep and goats, and to have been partially tanned. The Scrolls date from the third century BCE to the first century CE, based on historical, paleographic and linguistic evidence, and confirmed by carbon-14 dating.

In considering options for the exhibit housing, it was clear that a modular system that would require no direct handling of the scrolls during the exhibit period was needed. Another focus was to create a system that would minimize changes in relative humidity and would avoid any flexing and movement of the fragments. The scrolls were being exhibited and stored between venues in institutions with good environmental conditions and monitoring; all scrolls would be hand carried between venues. It was considered preferable to avoid the use of adhesives. To facilitate packing issues, the outer dimensions for ten of the twelve fragments were standardized.

A layered system that formed a "package" was developed, as illustrated. The acrylic sheeting filters ultraviolet radiation and provides a physical barrier as well as rigidity to the package. A spacer below, made from alkaline buffered rag board, separates the scroll fragment from the the acrylic sheet. Two mats were cut to hold stretched pieces

of polyester netting (Tetex- aka Stabiltex). The openness of the net weave and the color allowed viewing of the scroll fragment. None of the scroll fragments showed evidence of the skin softening due to gelatinization, as has been reported in some fragments that were subjected to higher humidities. If this type of softening and gelatinization had been evident, and/or if the environment was not to be controlled, this system would not have been chosen. The polyester fiber is smooth and has long term stability. Silk has been used in other contexts for related housings; it has a scaled fiber morphology and has less long term stability. Polyvinyl acetate (pva) emulsion was applied to the inner side of each mat, allowed to dry and the polyester net was applied in position with a tacking iron. The weave orientation of the polyester net on the second mat was askew to the first to minimize the possibility of a moire effect when placed together. Double sided 3M 415 acrylic tape was applied to the inside of one of the mats. The scroll fragment was placed between the two net mat layers, held together by the tape. The fragment was held in position by sewing around the outside of the fragment (not touching) using thread from another piece of the polyester netting. The sewing was visible only in some lighting situations, and was generally note seen by the viewer. The next layer was a natural, unbleached, washed airplane linen attached with pva emulsion (heat activated) to a rag board window mat. The linen provided an aesthetically pleasing background layer for viewing the scroll fragment. Below this were two layers of acid free blotter as a cellulosic relative humidity buffer. A silica gel tile would provide even greater buffering capacity, however, loose silica gel should be avoided due to the risk of stray gel in the package. An activated charcoal tile might be a useful addition to adsorb any volatile materials. The edges of this layered package



Drawing by Elizabeth Miller

were held together by two layers of J-lar acrylic tape along all four edge sides. Removal of the fragment from the package is fully possible.

The scrolls in their packages were displayed in exhibit cases buffered with silica gel, at an angle not exceeding 18 degrees. The shallow angle was intended to avoid potential pressure on brittle edge, by distributing the weight overall. The exhibit halls were all environmentally controlled and monitored. Lighting (max.3-4 footcandles) was viewer activated through infrared or button systems. The relative humidity was kept between 45-50%, with temperature 68-72 degrees F. Due to the package housing, the scrolls were quite easy to monitor during the course of the exhibit in terms of shifting, breakage, etc. Photographs and diagrams assisted in recalling details of staining, undulations, etc. This system or a variation thereof is being considered for long term storage.

Other possible options for mounting the fragments might have included the following, however were not considered appropriate in this context. Polyester encapsulation was not appropriate due to the delamination of some of the fragments, three-dimensionality of the support, aesthetic considerations and distracting glare. Hinging with Japanese tissue or a related material was not used to avoid any future need to remove the hinge in changing the housing. Straps or half moons did not seem aesthetically appropriate and in some cases would have been difficult to apply given the brittleness of some of the fragments.

18.6.6. Special Considerations for Nineteenth Century Fine Art Prints on Parchment (Jane Smith and Victoria Bunting)

History: The use of parchment as a substrate for fine art climaxed at the end of the nineteenth century in conjunction with the desire for *objet de luxe* reproductive prints in Europe and North America. In order to control the number of proofs per plate, regulating bodies, such as the Incorporated Printsellers' Association, were established in London. Prints produced under this Association's guidelines can be identified by the hand-written signatures of both the engraver and the painter below the image, and the absence of any engraved inscription except for the publication line. Artist's proofs always had the Printsellers' Association stamp in the lower left hand corner. (*An Alphabetical Listing of Engravings at the Office of the Printsellers' Association, London, from 1892-1911 Inclusive*, 1912).

Of the tens of thousands of prints pulled from a typical plate, 125 - 250 of these were apparently artists proofs on parchment (*An . . . Printsellers' Association* . . . 1912). A variety of subject matter was represented in parchment prints of the late nineteenth century. Landscape images were commonly reproduced as prints on parchment at this time, as were dramatic scenes after Pre-Raphaelite paintings by William Holman-Hunt, Sir Lawrence Alma Tadema and others. Nineteenth century *de luxe* edition reproductive prints are often on a split skin substrate and can measure from 45 - 55 cm by 65 - 80 cm.

Since the ink is never absorbed into the skin but rather, spreads under the pressure of the press, the print will have a gorgeous velvety texture, which may be easily disturbed during conservation treatment. Treatment options for these objects are limited because of the fragile surfaces of the ink, which are easily abraded and which may detach if the supports are flexed too much, and because of the inherent weakness of split skins.

The modest pressure used during printing may help to explain the faint or even absent platemark of many prints. Jenkins suggests that the platemark could be lost in the pressing after the printing. The platemark could also be lost in the mounting of the parchment to the backing board in preparation for framing.

Since these prints on parchment were deluxe versions of printed editions on paper, they also were expected to be relatively flat. These prints may be found glued down to a rigid support which is quite possibly their original mount. Catalogues of the period note that publishing companies such as the Fine Arts Society would do mounting of prints for the buyer (Sparrow, 1926; McIntosh Patrick, 1993). The original mount may be of poor quality materials which should be removed. The consequences of restraining skin, which has its own inclinations to move, accompanied with prolonged exposure to fluctuating relative humidity and temperatures, can be damaging to prints. Problems include cockling, splitting, tightening like a drum, and pulling away from the support.

Treatment: Removal of Adhered Matting and Mounting Boards

The brittle and broken backing board and window mat may be removed from the sheet of parchment mechanically, dry with spatulas and with Methyl cellulose (A4M high DP) poultices if the adhesive is water soluble. (See AIC/BPG/PCC 10. Spot Tests.) While this technique may remove some of the adhesive, there still may be residual adhesive in and on the skin. Although parchment is much more resistant to abrasion than is paper, it is still possible to abrade its surface, especially on the degraded edges.

Thin accretions of adhesive and mounting materials may be removed by swabbing with saliva and blotting the surface dry. If moisture in any form is applied, deformation where hot animal glue was applied originally in the mounting process may become more pronounced.

To provide access to the inside of folded edges, the crease of the fold may be swabbed with undiluted absolute ethanol to gradually relax it. One consequence of this process is that tidelines may result in discoloured skins. The tide lines may be reduced by feathering the hard edge with ethanol.

Surface Cleaning and Disinfecting Mold Covered Areas

Superficial surface grime and surface mould may be removed by swabbing with absolute ethanol in non -image areas only. Eraser cleaning as applied in paper conservation may be used for non-image areas. In image areas, loosely adhered accretions and mould may be picked up with a kneaded eraser with the aid of the stereo binocular microscope. Tenacious accretions such as dots of paint can be broken up with the point of a scalpel and the fragments dusted off by brush or air from a photography bulb/hurricane blower.

Review of current knowledge and treatment options, offer no acceptable method for minimizing the staining caused by mould and matting materials.

Retensioning

In retensioning parchments the surface characteristics of the ink and the image dimensions must be carefully maintained. The precise square shape of the image is important in keeping with the pristine surface and aesthetic qualities considered

desirable in prints from this period. Breaks and thinned areas already present in the skins must not be accentuated.

There are numerous ways to retension parchment. These prints on parchment, may withstand only minimal tensioning. One method to apply minimal tensioning is as follows. Construct a wooden strainer of dimensions two to three inches larger than the object. Hammer galvanized nails around perimeter on one side of strainer at one inch intervals, leaving heads protruding. Make a grid pattern using fishing line wrapped around the nail heads. This will be used to support the object in the humidity chamber. Elastics are used to attach bulldog clips to each nail. The clips should be padded with blotters, felts, Pellon, etc. to protect the parchment from indentations. These clips will be used to tension the parchment once it is humidified by adjusting the elastics around the nails. During humidification the parchment may be held with a few bulldog clips on each side to prevent curling or extreme distortions. After sufficient humidification, additional clips are applied and the tension is adjusted using the elastics. After a few hours, the parchment may be removed from the strainer and placed between blotters, felts and plate glass. If appropriate, more weight may be added. In most cases complete flatness may impossible to achieve without risk of damage to the image or distortion of dimensions. (Jane Smith and Victoria Bunting)

References:

An Alphabetical Listing of Engravings at the Office of the Printsellers' Association, London, from 1892-1911 Inclusive. 1912. London: Printed for the Incorporated Printsellers' Association.

Sparrow, W.S. 1926. *A Book of British Etching from Francis Barlow to Francis Seymour Haden.* London: John Lane The Bodley Head Limited.

Personal correspondence, 1993, Mr. Andrew MacIntosh-Patrick, Fine Arts Society Archives, 148 Bond Street, London W1Y 0JT, England

18.6.7. Case Study of U.S. Public Laws: Record Copies on Parchment (Catherine Nicholson)

Following practices established in England, the official record copies of U.S. public laws were engrossed, that is, hand-written in a formal calligraphic hand, on parchment supports. The initial words or lines of the text would be written with larger, thicker, thus "engrossed" letters, built up of multiple parallel pen lines with the space between parallel lines hatched or filled in solidly with ink. As early as 1802, the engrossed initial words were printed by letter press on the parchment, with the remainder of text handwritten in iron gall ink on a parchment support, generally unsplit.

Continuing into the first quarter of the nineteenth century the parchment supports were large, up to about 30 by 34 inches. While laws of shorter length were written on one side, generally the toothier flesh side of individual parchment leaves, longer laws were written front to back, with text running from top to bottom on the recto and then from bottom to top on the verso. For longer texts, faint pencil guidelines were made, sometimes between holes pricked in the side margins. The practice of writing from bottom to top on the verso indicates that initially the separate leaves were joined together along the top edge, a practice common in English public records. The U.S. Constitution similarly has a set of vertical slits in the top margin of each parchment

leaf, with faint blue coloration on the split edges apparently from ribbon used to hold the several pages together. (They are however only written on the recto.)

Until the late nineteenth century, the Constitution is known to have been rolled, and for some period of time the rolled parchment leaves were stored in a tin cylinder. All the large parchment public laws were probably originally stored rolled. The office entrusted with their custody during the nineteenth and early twentieth century was called the Bureau of Rolls at the State Department. Physical evidence of rolled storage remains in parallel horizontal ridges or creases, and in patterns of stains that repeat along the length of a parchment leaf. They may later have been bound into structures with leather-covered spines, possibly in the late nineteenth century, as small remnants of brown leather were found glued along the upper edge of one early public law. In 1926 the Government Printing Office bindery devised a postbound structure for the large early public laws, which continues in use today. The shorter individual leaves were stitched and glued with animal glue along their top edges to buckram tabs. These buckram tabs and the top edges of the longer parchment leaves were then sewn together onto a buckram tab into signatures of about ten leaves. Each signature had a reinforced buckram top edge with grommet holes held into a large locked post bound structure, measuring 33 x 40 inches closed. Several signatures of Public Laws are grouped in a post binding by session of Congress, arranged by date of approval and numbered sequentially.

In 1824, smaller parchment leaves ca. 15 x 22 inches began to be used for public laws. The parchment was split, making it thinner. Faint blue lining served as a guide in writing the manuscript text, below the engrossed initial lines printed by copperplate engraving. Text was generally written only on the recto. By the middle of the century the use of red and/or blue ink border lines in the margins around the text became common. The parchment leaves were sewn along the left edge into leather bindings arranged by session of Congress. In 1893, the size of the parchment leaves decreased even further to ca. 10 x 15, because the text was now printed on the recto only within a border line of double red lines. The leaves were bound along the left edge into volumes.

In 1920, the use of parchment for record copies of laws was discontinued, and a high quality heavy weight off-white wove paper was introduced. Text was printed within a red line border in the margins, with original pen and ink signatures on the final page.

The National Archives has had a practice of making "red line" copies of public laws upon request which can on first glance be confused with the originals, as the red line border paper used is the same used for printing public laws. The copies are produced on a xerographic copier and can be distinguished from originals on close examination.

Though they are not public laws, the ratification copies of the Constitution and Bill of Rights were also executed on parchment supports. Ratification copies, which were sent to each state for approval, are in addition to the official record copy retained by the U.S. government, so more than a dozen copies were originally created. Ratification copies typically show evidence of having been folded up for transport to the states, with an endorsement or address written on the exterior of the folded up document.

18.6.8. Case Study: The Declaration of Independence (Elissa O'Loughlin)

The Declaration of Independence, the Constitution (five pages) and the Bill of Rights were sealed in glass and bronze cases in 1951-52. The work was done by the National

Bureau of Standards under contract to the Library of Congress. The parchments are held by compression on several sheets of a high alpha-cellulose paper within the cases which contain humidified helium. Evelyn Erlich and George Stout treated the Declaration for the Library of Congress in 1942. The upper right corner had become detached in part due to the uncontrolled exhibition environment at the Library. A circular loss about 1/2" in diameter above the letter "m" in "America" was inserted with new parchment. Minor tears and small losses were mended with Japanese paper and wheat starch paste, and pulp fills were made with Japanese paper fibers toned with Winsor and Newton watercolors. For his work on the Declaration, George Stout was named "Honorary Consultant in Parchments" by Archibald MacLeish, then Librarian of Congress.

Verner Clapp asserted (Special Libraries, Dec., 1971) that the reason for the poor condition of the Declaration was that the parchment was "not even an excellent sheet of parchment to begin with; apparently it was a home-made (colonial-made) piece of parchment found fairly quickly in the markets of Philadelphia." Clapp's assertion has not been confirmed, and no source for the information is given in the article. However, there were parchment makers in Philadelphia and elsewhere in the colonies at the time of the Revolution. As early as 1748, David Hall (partne of Benjamin Franklin) advertised in the Philadelphia Gazette tht "very good" parchments were made locally by Joseph Wood were available for sale at the Post Office. Later, in the April 1779 edition of The New York Journal, Robert Wood advertised parchment made by himself for sale to stationers and large quantity users. Benjamin Franklin mentions a Robert Wood whose parchments were said to equal those of English import in quality. Other parchment makers were working in New York CIty and in Alexandria, Virginia in the latter part of the eighteenth century.

18.6.9. Storage and Display of Parchment: Case Studies (Dr. Nathan Stolow)

The recently published studies[1] of the mechanical and biological properties of parchment and the recommendations under certain circumstances for reducing the accepted R.H. norm to the level of 30 ± 5% (albeit for modern vellum) is cause for concern, especially so for archival conservators and custodians of parchment documents, manuscripts and ancient artifacts of similar proteinaceous composition. For many years it had been established that old parchment, from the Dead Sea Scrolls to the U.S. Bill of Rights, required an ambient level of 50-60% to maintain suppleness, ease in handling, and geometric stability in display situations. The goal in climate controlled cases was to achieve constancy in R.H. control over extended periods of time. Careful examination of the condition of parchment artifacts maintained in such cases showed that surface features were well preserved.

Thus, dimensional relationships and any distortions out-of-place remained fairly constant. Where documents were displayed flat, without appreciable restraints, it was determined that the parchment was sufficiently relaxed at the level of 50-60% R.H. to justify the light restraints to anchor the document in position. Likewise, rare manuscripts exhibited at fixed (or occasionally variable openings) were less likely to be physically stressed when displayed at the recommended humidity levels.

My experience with parchment documents and manuscripts goes back some twenty-five years, particularly in the specialized field of controlled climate cases and exhibitions technology. I was responsible thus for the environmental and conservation

standards for the display and travel of the Book of Kells and other manuscripts[2]; the Magna Carta (Brudenell/Perot); and more recently the Bill of Rights (Virginia)[3]. Summary descriptions of these projects with annotations relevant to ongoing study of the reactive properties of parchment are included here. In all instances the levels of R.H. in the 50-60% range were recommended by the institutions, archives, and consultant manuscript conservators themselves as conforming to past environmental history (display and storage) and desirable physical maintenance.

A. Kells and Other Irish Treasures.

The exhibition, "Treasures of Early Irish Art: 1500 B.C. to 1500 A.D.," included treasures from the Trinity College, Dublin; the Royal Irish Academy; and the National Museum of Ireland, and traveled from Dublin to the U.S.A. and to various U.S. major institutions from October 1977 to May 1979. Included in the exhibition were two volumes of the Book of Kells, the Book of Durrow and Dimma, Armagh, and Stowe manuscripts. This exhibition, in revised and reduced form, also traveled in Europe, 1980-83.

Required Environmental Standards: 60 ± 2% R.H.; 66-72°F.

Case Description: Externally back-lit acrylic cases with conditioned silica gel, and these display units (5) were housed in a large display structure with temperature control, moderate R.H. control, and various security alarms. Light levels were strictly controlled -- ultraviolet free at 5 foot-candles at document surfaces.

Condition Monitoring: Daily R.H. and temperature monitoring by resident curator, and by consultant during site visits at each exhibition venue. Environmental reports sent regularly to Dr. Stolow and Irish authorities, and instantly evaluated for any possible remedial action, if required.

Photographs were taken initially of selected details of the Books of Kells and other documents and these areas are restudied at different times to determine if any changes were taking place. Observations of cockling and other surface defects particularly noted.

Comments: The level of 55-60% R.H. was rigorously maintained for the 18 month display period, and also in transit. Condition studies showed that the exhibited manuscripts and documents remained supple and flexible, and all decorative elements were well preserved.

Specialists Concerned and Acknowledgements: Dr. N. Stolow, Conservation Consultant; Anthony Cains, Manuscript Conservator, Trinity College, Dublin; Stuart O'Seanoir, Keeper of Manuscripts, Trinity College, Dublin.

B. Magna Carta - Brudenell/Perot.

This version of the Magna Carta, dating to 1297, was purchased by Ross Perot of Dallas, Texas, in 1984 from the Brudenell Estate in Great Britain. The parchment document measures 14 1/2" wide by 17 3/4" long, is written in Latin, and has an attached seal. After conservation treatment by Don Etherington and assisted by James Stroud, it was prepared for travel in a specially designed climate controlled case and outer security container by Nathan Stolow. The overall exhibition design was executed by Staples and Charles of Washington, D.C. The itinerary covered the

period 1985-86, including showings in Washington, D.C.; Philadelphia, Pennsylvania; Dallas and Austin, Texas; and Boston, Massachusetts.

Required Environmental Standards: 52 ± 2% R.H., 68-74°F. 5 foot-candles illumination ultraviolet free, vibration and shock protection in transit; nitrogen environment; pollution control.

Case Description and Condition Monitoring: At the end of the tour the document was exhibited again in the Rotunda of the National Archives. In 1990, Dr. Stolow redesigned the climate controlled case, installing a permanent one fabricated in stainless steel and housing the document on a special platform with securing devices modified by Don Etherington. The R.H. control was achieved by preconditioned silica gel maintaining a consistent level of 52 ± 2% at ambient Rotunda temperatures. This climate and light controlled case was fitted with various probes, including that for R.H. and temperature (Vaisala Hygrometer) reading the internal conditions from the externally rear-mounted meters. At the time of setting up, and on an annual basis, the case was charged with 99% nitrogen gas (at 52% R.H.), the level of residual oxygen determined on-stream with a Beckman oxygen monitoring device. To the extent possible, all internal materials used in the climate controlled case were deemed to be pollution free. To limit any residues of pollutants building up within the case, a quantity of activated carbon pellets was placed in a dust-free porous container under the platform of the displayed document alongside the silica gel bed.

In accordance with conservation standards, the light level infringing on the document was limited to 5 foot-candles, ultraviolet free. Outside of visiting hours, the display front of the Magna Carta installation was covered over with an opaque panel to limit the cumulated light exposure on the document. The external display housing in marble and anodized aluminum was designed by Staples and Charles. The external viewing glazing (spaced away from the climate control module) was of 1 1/4" Lexan, a material resistant to heavy blows, mechanical shock, and even bullet proof! This permanent installation remains as redesigned in 1990, and functions extremely well. Some typical environmental data, R.H. and temperature levels inside the case are given in Table I, and for the corresponding ambient conditions in the Rotunda external to the case in Table II.

Comments: The level of 52 ± 2% R.H. was very consistently maintained to date (6 years at least) at ambient conditions in the range of 68-74°F approximately. Periodic examinations at the "microdetail" level of selected areas and observations on the degree of suppleness of the document by Don Etherington confirmed that the display mode conditions were quite suitable for conservation purposes. An interesting proof of the stable surface configuration was obtained by taking periodic raking light macro-photos of selected readily repeatable areas under precisely controlled light angles. This was carried out by James Stroud and the author, and verified that the document was dimensionally stable and was in a suitable "equilibrium" state.

Specialists Concerned and Acknowledgements: Ross Perot, Bette Perot, Merv Stauffer, Dallas, Texas; Dr. Nathan Stolow, Conservation Consultant; Don Etherington, Manuscript Conservator; James Stroud, Manuscript Conservator; Linda Brown, Assistant Archivist, and Norvell Jones and her conservation staff

members of the National Archives; Staples and Charles, Exhibition Designers, Washington, D.C.

C. The U.S. Bill of Rights (Virginia Version).

This parchment document is the original Virginia copy of the Bill of Rights, and was on loan by the Virginia State Library and Archives, Richmond, for the purpose of a 50 state national tour starting in Barre, Vermont, October 10, 1990, and ending in Richmond, Virginia, on the 200th anniversary of the U.S. Bill of Rights, December 15, 1991. The document is approximately 34" wide by 32" high (maximum dimensions). The preparation phase for the tour and the tour expenses themselves were underwritten by the Philip Morris Corporation. As Conservation Consultant, I was responsible for the design and construction of a climate controlled case to maintain constant R.H. levels, light protection, and to design as well a transportation container to travel the environmental module from state to state. The overall exhibition concept was designed by Associates and Ferren of Long Island, N.Y., who worked closely with me to ensure that my controlled climate case meshed in with the "high tech" devices used for the display mode. A special mobile track system was used underneath the public waiting rooms (above) to bring the document and its case by an elevating device into view. There were two such elevator shafts for viewing in alternate stations. The glazing at the viewing platforms was of bullet-proof 1 1/4" thick Lexan.

As can be imagined, a 50 state tour with up-to-date visual devices, video screens, posters, etc., involved a veritable army of staff and personnel ranging from technical and conservation experts to security personnel, and all sorts of installers and movers.

Prior to each state's public opening, the document was checked, as was the environmental monitoring system. This consisted of a Vaisala Hygrometer (R.H. and temperature sensors) hooked up to computers in an equipment trailer nearby. Readouts of R.H. and temperature could be ascertained in a variety of formats at any time (during and outside of exhibition hours).

Case Description and Condition Monitoring: Silica gel conditioned to 50-54% R.H. was used for maintaining the R.H. levels to an achievable range of 51-55% R.H. throughout the tour. The stainless steel case with 1/2" thick acrylic glazing was periodically purged with nitrogen gas to reduce the oxygen level to 1% or less. Pollution control devices were also utilized as described earlier in the Magna Carta project. The ambient temperatures were maintained by a separate air conditioning system keeping the exhibition case to within the range of 68-72$ F.

Periodic inspections of the document by myself, Don Etherington, and Dr. Manarin (of the Virginia State Library and Archives) confirmed the efficacy of the R.H. levels in maintaining the Bill of Rights parchment in a supple and relaxed state throughout the tour.

Comments: The Bill of Rights was adequately conserved and protected at the R.H. level of 51-55% R.H. with light levels controlled to 5 foot-candles. The constancy in dimension and configuration of the Bill of Rights was attributed to the controlled case environment.

Specialists Concerned and Acknowledgements: Dr. Louis Manarin, State Archivist, Virginia State Library and Archives; Dr. Nathan Stolow, Conservation Consultant; Bran Ferren, Associates and Ferren, Designers and Staff Engineers; Don Etherington, Manuscript and Book Conservator.

Also work credited in the following press releases:

* October 6, 1990: "200th Anniversary of the Bill of Rights. Preservation on Tour: Two Conservators and a Design Wizard Share Preservation Techniques for the Bill of Rights." Philip Morris Companies, Inc., New York, N.Y., 6 pp.

* April 24, 1985: "1297 Magna Carta on Loan to National Archives." National Archives, Washington, D.C., 2 pp.

References and Notes.

1. Hansen, E. F., S. N. Lee and H. Sobel. "The effects of relative humidity on some physical properties of modern vellum; implications for the optimum relative humidity for the display and storage of parchment." Journal of the American Institute for Conservation 31, no. 3 (1992): 325-342.

2. Irish Treasures Exhibition and Kells Books, etc., described in Stolow, Nathan, Conservation and Exhibitions, London: Butterworths, 1987, pp. 68-69, 205, 210-211.

3. Descriptions of my consultancy work on the Magna Carta and Bill of Rights projects were included in a paper given to the Virginia Conservation Association meeting in Richmond, VA, September 26, 1991: "Microclimate Case Technology for the Virginia Bill of Rights and for the Magna Carta."

TABLE I

MONITORING OF R.H. AND TEMPERATURES OF MAGNA CARTA IN CASE DISPLAY AT THE NATIONAL ARCHIVES (ROTUNDA) 1992-1994 (various intervals)

Date	Time	RH* %	T_1* °F	T_2** °C
3-19-92	2:15 p.m.	53	72.2	23.0
4-1-92	2:30 p.m.	52	68.5	21.0
4-13-92	8:17 a.m.	52	67.7	20.0
4-24-92	3:00 p.m.	52	68.5	21.0
5-1-92	12:30 p.m.	52	67.4	20.0
5-22-92	9:30 a.m.	52	67.6	20.0
7-8-92	12:30 p.m.	52	67.5	20.0
7-31-92	10:00 a.m.	52	67.5	20.0
8-25-92	9:00 a.m.	52	67.5	20.0
10-28-92	10:00 a.m.	52	67.5	20.0
11-1-92	8:30 a.m.	53	68.2	20.0
11-11-92	8:30 a.m.	52	68.3	22.0
11-14-92	8:30 a.m.	53	69.2	22.0
12-23-92	9:30 a.m.	53	68.2	22.0
1-13-93	8:45 a.m.	53	70.1	22.0
1-19-93	2:00 p.m.	53	70.3	23.0
1-22-93	11:00 a.m.	53	71.0	22.0
2-16-93	10:00 a.m.	53	70.8	23.0
3-12-93	10:00 a.m.	53	70.2	23.0
3-22-93	9:00 a.m.	53	70.4	22.0
4-23-93	9:00 a.m.	53	66.3	20.0
5-7-93	10:00 a.m.	53	66.6	20.0
5-11-93	10:30 a.m.	53	66.9	20.0
5-25-93	8:30 a.m.	53	67.5	20.0
6-9-93	8:30 a.m.	53	63.8	18.0
6-18-93	9:30 a.m.	53	68.7	22.0
6-24-93	8:30 a.m.	53	68.5	22.0
6-28-93	9:45 a.m.	53	68.6	22.0
6-30-93	11:30 a.m.	53	68.6	22.0
7-2-93	9:00 a.m.	53	68.5	22.0
8-27-93	9:00 a.m.	53	68.5	22.0
9-17-93	12:00 p.m.	52	68.4	22.0
9-20-93	9:30 a.m.	53	68.5	22.0
10-21-93	9:30 a.m.	53	68.6	21.0
11-8-93	9:30 a.m.	53	70.1	22.0
3-9-94	10:00 a.m.	53	67.7	21.0
4-7-94	9:30 a.m.	53	67.0	20.0

Table I
Monitoring of Magna Carta
R.H. and Temperatures
Page 2

Notes:

* R.H. (%) and temperatures (T_1, ^{o}F) measured from an electronic high quality Vaisala Hygrometer probe positioned under the Magna Carta document holding platform. The readout is from the meter component at the exterior back end of the display case. The R.H. readings are accurate to $\pm$ 2% R.H. units for this high quality hygrometer. The meter readings are rounded off to the nearest whole number (decimal fractions are not significant).

** The temperatures are taken from a small thermometer mounted on top of the display platform, next to the document (left side). Measurements are in ^{o}C for this thermometer.

TABLE II

R.H. AND TEMPERATURE RECORDS OF AMBIENT CONDITIONS IN ROTUNDA FROM THERMOHYGROGRAPH CHARTS 1993-1994 (various intervals)*

Week of:	R.H. Range (%)	Temp. Range (°F)
January 4, 1993	39-52	66-70
February 1, 1993	35-44	67-72
March 1, 1993	34-51	69-72
April 5, 1993	40-56	66-70
May 4, 1993	50-58	66-69
June 1, 1993	50-66	63-70
July 12, 1993	50-63	67-70
August 2, 1993	48-60	66-70
August 9, 1993	48-60	67-70
November 29, 1993	40-55	66-70
January 10, 1994	28-55	62-72
February 7, 1994	34-48	68-72
March 28, 1994	44-56	65-69

Notes:

* A selection of thermohygrograph chart records for the period (covering the seasons) from which the minimum and maximum readings were read and shown here as R.H. and temperature ranges.

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