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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 Arguments against the use of these outdated treatments have been included.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 understanding 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 (sofer) 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 (glair), 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 joints 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 joints 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-term 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 selected over other adhesives for the repair of the 11th c. English Domesday 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 Henke, 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 circumstances, 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 acrylic 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 alcohol/ 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 desiccated 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 available 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 sieved. 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 Crepe: A very fine weave silk fabric, often called crepe, 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. Crepline 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, Sovereign, 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, Sovereign, 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 dislodged. 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 consolidation, 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 damaged 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 obscured 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 contemporary 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 techniques. 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 immersed 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 parchment 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 significantly 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 consolidant 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, Sovereign 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 humidification 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 humidification 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 at 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 polyethylene sheeting is sometimes used for folded sheets, such as book pages, that can be draped over the lines.

2. **Lauscaux Chamber:** The Lauscaux chamber developed and described by Olivier Masson, which is available commercially from Lauscaux 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 humidification 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 humidification/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.170-171; 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