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PREVENTIVE CONSERVATION OF AMBER: SOME PRELIMINARY INVESTIGATIONS

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Abstract.—Deterioration of amber in museum collections is a well-known but poorly understood phenomenon. In an attempt to identify some of the destructive agents, small pieces of Dominican amber were exposed to high concentrations of substances that might be encountered in a museum storage or display environment, including common air pollutants, volatile biocides, and cleaning agents. Several of the substances caused almost immediate surface disintegration. Fresh surfaces were less affected than surfaces that had been exposed to air for a number of years. Further investigations are being carried out.

Deterioration of amber both before and after its inclusion in collections is a problem that has long frustrated collectors, curators, and conservators. It appears primarily as darkening, especially of transparent samples, and a variety of forms of surface cracking, crazing (a coarse network of surface cracks, Fig. 1) or crizzling (a very fine network of shallow cracks, Fig. 2). The network of cracks may result in exfoliation or, on deeper penetration, in total disintegration. While there is a wealth of literature on conservation in German, literature on the subject in English is very scarce and widely scattered (see Beck *et al.,* 1966; Beck, 1982). Alteration of amber is assumed to be caused principally by oxidation in air (Beck, 1982). Oxidation is said to occur even in the absence of light, but to be aggravated by UV light (Beck, 1982). Undoubtedly other factors also contribute to the deterioration.

A number of protective measures have been attempted, all striving to isolate amber from the air. These include storage in closed containers with or without immersion in water or some other liquid, and coating the amber surface with a variety of natural and synthetic substances. Many of these coating or immersion substances have been found to have some long term deleterious effect on the amber and all constitute a contamination of the amber for further chemical or spectrographic studies. Closed containers are obviously an inappropriate medium for display. The Royal Ontario Museum plans to display a significant collection of Dominican amber with organic inclusions in a forthcoming permanent gallery. This study arose from a desire to minimize environmental risk to the amber in designing the exhibit.

MATERIALS AND METHODS

Most deterioration of amber has occurred over a relatively long time—anywhere from decades in a museum drawer to millenia in a Mycenaean Greek cache. We accelerated the process by exposing the amber to higher concentrations of the test substances than might normally be encountered. This was done in the hope of rapidly identifying the harmful substances that required further investigation. Unfortunately this may have introduced misleading complications into the experiment.

Potentially harmful substances or conditions may be grouped into four categories: common air pollutants—ammonia, formic acid, hydrogen sulphide, acetic acid; biocides—naphthalene, paradichlorobenzene, camphor, DDVP (dichlorvos), and hydrogen phosphide (Phostoxin); cleaning agents—ammonia, sodium bicarbonate, sodium hypochlorite; and physical conditions—relative humidity, temperature, light. Only the first three categories are considered in this preliminary study.

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Figure 1. Typical surface crazing on a specimen of Baltic amber.

Small pieces of amber from the Dominican Republic were exposed to a variety of substances or conditions commonly encountered in a museum display or storage environment. The ROM Department of Mineralogy kindly provided polished lozenge shaped blocks, relatively pale and transparent (catalogue no. M25968). Samples were cut into several pieces, each retaining at least one original polished side. One piece from each sample was kept as a control for comparison of colour and original surface.

A small piece of transparent amber was placed in a glass jar with a tight-fitting lid, along with a small amount of biocide crystals or liquid on a piece of cotton, not in contact with the amber. This produced a high vapour pressure of the particular substance in the jar. The amber was removed periodically and examined. Photographs were taken before and after each process.

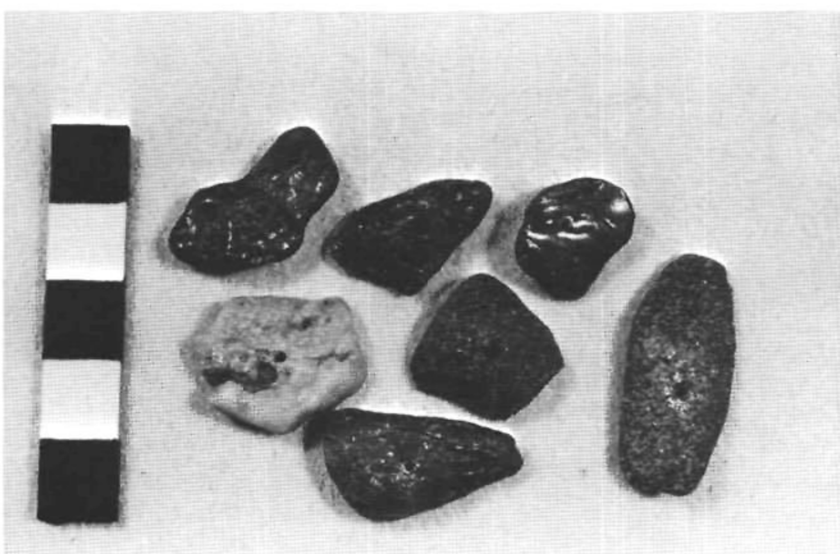

Figure 2. Surface crizzling of archaeological amber beads.

Table 1. Results of exposure of amber to vapours of various pollutants and cleaning agents.

Substance	Duration	Result
Ammonia	24 hours	Darkening. On removal to air, immediate crizzling and exfoliation of polished surface.
Hydrogen sulphide	3 hours	Extensive crizzling and exfoliation over entire surface. Precipitation of white salt.
Formic acid	3 days	On removal to air, crizzling and exfoliation of polished surface.
Acetic acid	3 weeks	On removal to air, crizzling and exfoliation of polished surface.
High RH and sodium bicarbonate	1 week	On removal to air, extensive crizzling with white salt crystallizing on cracks and on surface (powder in contact with amber).
Sodium hypochlorite	4 weeks	No visible effect after repeated removal and re-exposure.

Results and Discussion

The results of exposure to various air pollutants and cleaning agents are shown in Table 1 and Figure 3. In most cases the amber reacted to the vapour by surface cracking, the only difference being the speed or intensity of the response. There was very little colour change other than that caused by the cracks themselves. Such a similar response to widely varying reagents supported the theory suggested by R. Waller (personal communication) that the reaction was physical rather than chemical. The high vapour pressure caused the substance to be absorbed by the amber, producing slight surface swelling. On removal to air, the substance de-

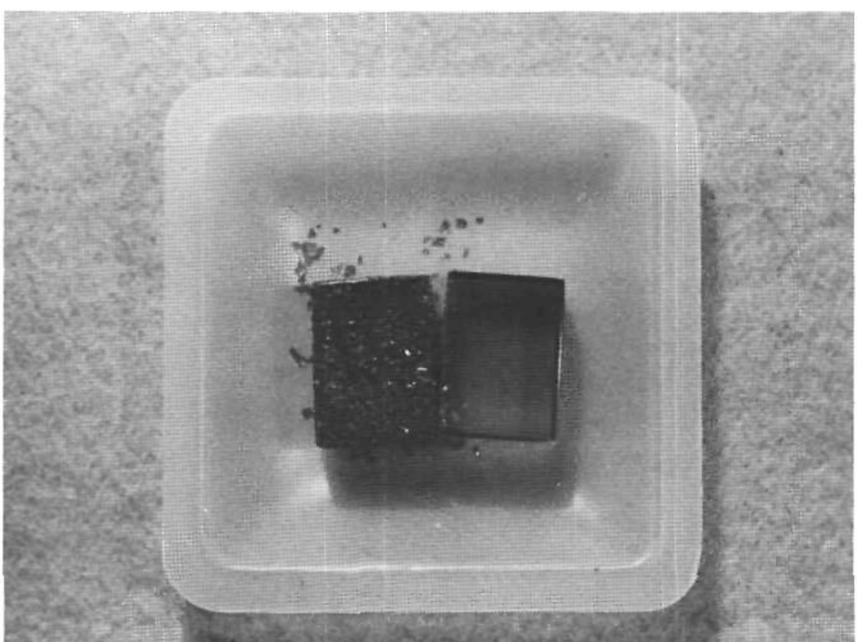

Figure 3. Amber after 3 days exposure to concentrated ammonia vapour. Control on right.

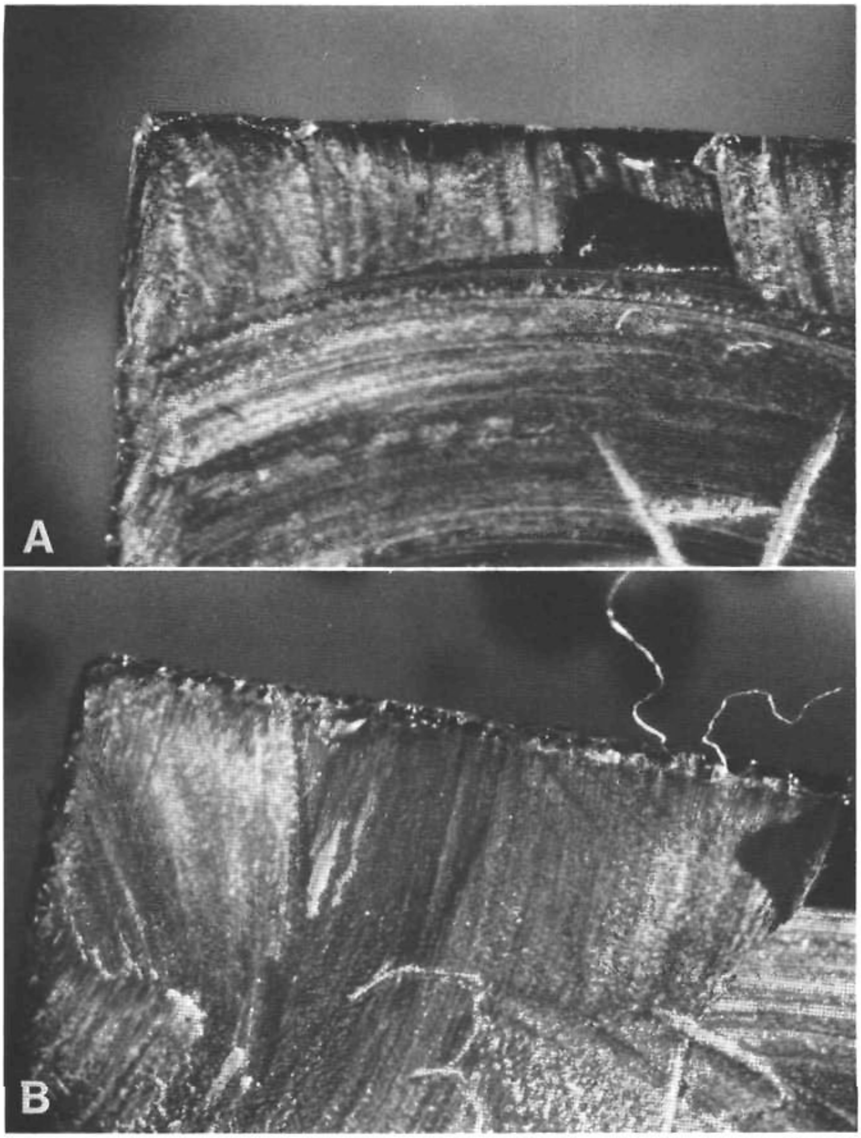

Figure 4. Cut surface of amber showing (A) penetration of surface alteration in control sample and (B) penetration of exfoliation layer in sample exposed to ammonia vapour.

sorbed rapidly and the resultant rapid decrease in volume caused the amber to crack. A similar phenomenon is observed on too rapid drying of waterlogged fossil bone or wood. The varying degrees of cracking may reflect differences in the amount and rate of volume change experienced. The fact that freshly cut surfaces were usually not affected suggests that previous oxidation somehow made the old amber surface more receptive to absorption of certain substances. The exfoliation penetrated only as deeply as the surface alteration noted on the control sample (Fig. 4A, B). This theory requires further investigation.

Paradichlorobenzene (PDB), naphthalene, and camphor are all common mu-

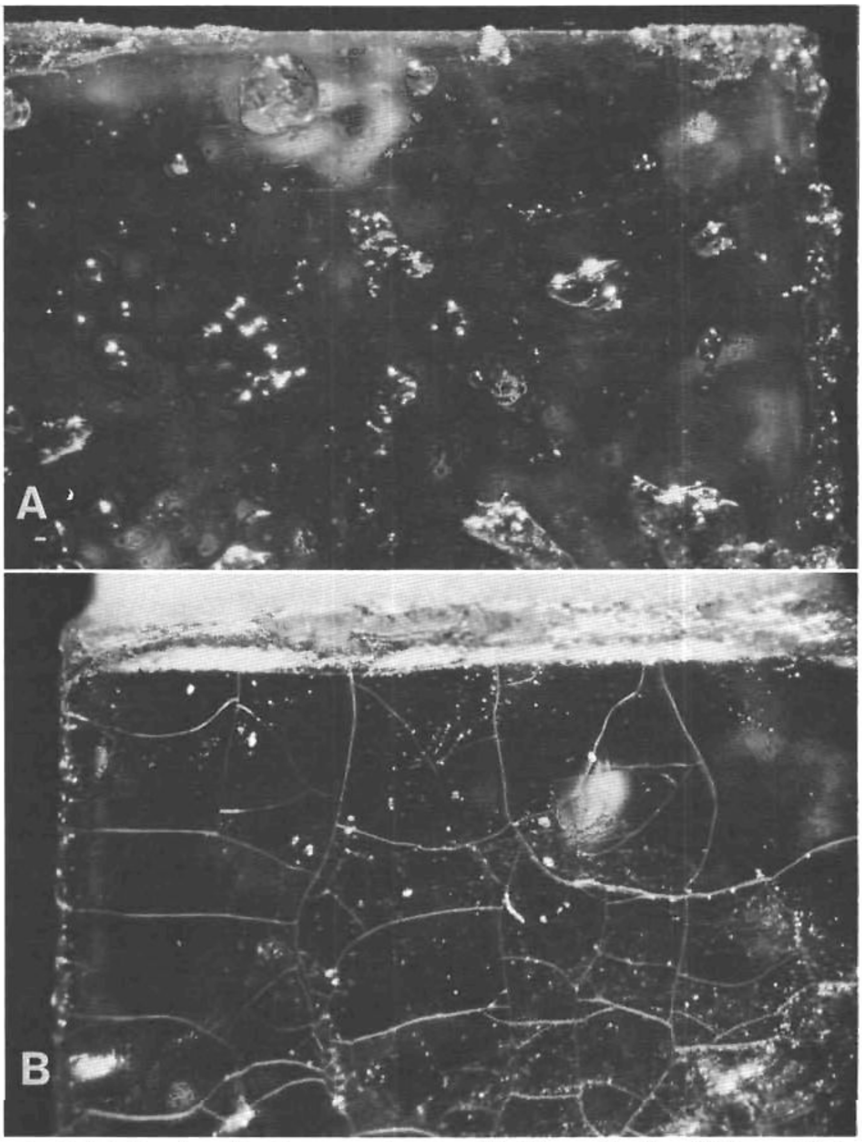

Figure 5. Polished surface of amber exposed to three biocide combinations (A) immediately upon removal and (B) after exposure to air.

seum fumigants and are used, singly or in combination, in household mothballs. Amber showed no adverse visible effects when exposed to any of these vapours alone over a period of several weeks. In combination, however, the three biocides formed a strongly hygroscopic mixture. The amber was suspended in the jar so as not to be in contact with the biocides. Within 24 hours the entire surface of the amber was softened (Fig. 5A). Coarse crazing, partly concealed by softening of the surface, became evident after the biocide evaporated (Fig. 5B). It is likely that the cracks developed as a result of the rapid decrease in relative humidity caused by the hygroscopic biocide mixture. The softening was due to partial solution of the amber in the concentrated biocide vapour.

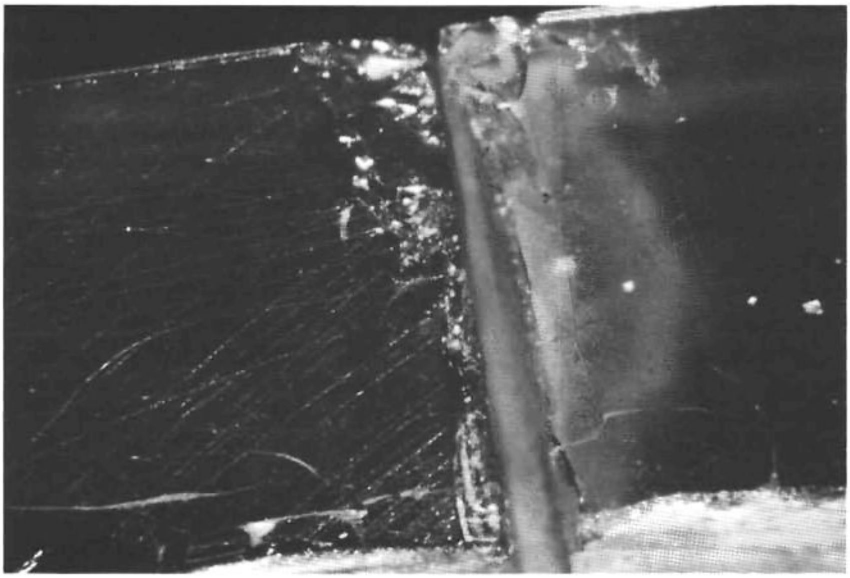

Figure 6. Polished surface of amber after exposure to DDVP vapour. Control on right.

Amber placed in a closed jar with DDVP for several days developed a series of parallel scratches on all polished surfaces that resembled mechanical abrasion. These marks deepened on exposure to air (Fig. 6). The scratches were not noticeable before the amber was subjected to the biocide, and on examination none of the control pieces showed comparable scratches. Microscopic scratches that remained on the surface after polishing may have been deepened by oxidation. Steve Williams (personal communication) has noted increased oxidation rates of many substances after exposure to DDVP.

Amber was exposed to fumigation with hydrogen phosphide (Phostoxin) at ambient relative humidity. After four treatments there was no visible change. Studies on other materials have shown that deleterious effects of fumigation with Phostoxin may not appear until after several exposures. The treatment will be repeated.

Summary and Future Studies

These crude preliminary experiments demonstrate the need for further investigation into factors influencing the deterioration of amber, in particular the nature of aged amber surfaces and the mechanisms of deterioration. Scanning electron microscopy might indicate structural differences between fresh and oxidized polished surfaces and exfoliated fragments. Infrared spectroscopy may indicate chemical differences between altered and unaltered samples. Previously coated samples should be tested to determine whether such treatment affects their sensitivity. There are many more substances that could be tested.

Ammonia, hydrogen sulphide, and formic and acetic acids should be retested at concentrations equating more closely to typical exposure levels. The concentrations of biocides used however do equate to real situations during case fumigation and storage. Clearly amber is sensitive to many chemical environmental components and care must be taken in routine fumigations and in choosing appropriate case materials for its storage and display.

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AN APPARATUS FOR MINIMIZING THE INFLUENCE OF CARBONIC ACID DURING SURFACE pH MEASUREMENTS OF MUSEUM MATERIALS

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Abstract.—An apparatus, consisting of a CO_2 extraction system connected to a specially designed glove box, is described for surface pH measurements of museum materials with minimal influence of CO_2. It is economical and potentially portable, and when used with a pH meter and surface electrode or microelectrode, it can provide accurate pH measurements with minimal effect to museum materials.

The determination of pH is useful for assessing the stability of museum materials for conservation purposes. Data on the acidity or alkalinity of materials associated with documentation and storage, and objects, as well as the effect of various treatments, can contribute to a better understanding of the preservation requirements of museum materials. Examples of such materials for which pH determinations have been made include paper (Clapp, 1978; Ritzenthaler, 1983), ink (Williams and Hawks, 1986), collagen (Balphe, 1948), leather (Fogle, 1985; Stubbings, 1977), fumigants (Williams *et al.*, 1989), herbarium materials (Clark, 1986), and fluid preservatives (Waller and McCallister, 1987). Methods for pH measurement in liquids could be destructive to many museum materials. A desirable alternative is the use of a pH meter with a surface electrode or microelectrode, which requires only a drop of water. This technique permits determination of pH on most dry surfaces with minimal effect to the object. However, the increased ratio of surface area to volume of a drop of water results in accelerated development of carbonic acid as carbon dioxide from the atmosphere is absorbed ($H_2O + CO_2 \rightleftharpoons H_2CO_3$). Carbonic acid development can cause pH of distilled water to drop to as low as 5.4. As the quantity of hydrogen ions resulting from the carbonic acid interferes with hydrogen or hydroxide ions from the material, it is possible to get misleading pH readings on the meter, particularly with conditions of low acidity or alkalinity.

Determination of pH values in minute quantities of water is more precise if done under conditions that are essentially free of carbon dioxide, such as a nitrogen saturated environment. The equipment required for creating such environments, however, tends to be both stationary and costly.

Experimentation resulted in the design of a CO_2 controlled chamber that is portable and inexpensive to construct and maintain, and that permits accurate and precise pH measurements of museum materials. This apparatus has been used successfully on a variety of proteinaceous (for example, keratin, tanned and untanned skin, and bone) and cellulosic materials (for example, textiles, paper products, and wood).

Methods and Materials

The objective was to maintain a water sample at a constant pH of 7.0 for an extended period of time, thus providing conditions for accurate pH determination. The apparatus includes a CO_2 extraction system attached to a chamber used for operating pH instrumentation.

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The CO_2 extraction system consists of an air supply followed with two containers of 10N NaOH solution, a container of water, and one or more desiccators, connected with plastic tubing (Fig. 1A). The tubing providing air to containers of fluid extends to the bottom to allow maximum air flow through the liquid; the tubing allowing the outflow of air truncates just below the rubber stopper. As the air supply is aspirated through the NaOH solution, the CO_2 reacts with OH^- to form a carbonate ($CO_2 + 2OH^- \rightleftharpoons CO_3^{-2} + H_2O$). At high concentrations of CO_3^{-2}, sodium carbonate will precipitate. The ability of the NaOH solution to absorb CO_2 is dependent on the amount of aspiration, the pH of the solution, and the amount of CO_2 already absorbed by the solution. Because the precipitated sodium carbonate causes the solution to become cloudy, it can serve as a visible indicator of the solution's condition; the clearer the solution, the more CO_2 can be absorbed. Extreme caution is required in making the 10N NaOH solution because the chemical is caustic, and its combination with water causes an initial exothermic reaction. For this reason plastic containers that could be affected by heat should be avoided. Glass containers should not be used because glass is soluble in NaOH. Polyethylene containers with screw-on caps are suitable. Any container used should be capable of sitting securely on level surfaces. The center of the cap is cut out to accommodate passage of plastic tubing while the remainder of the cap is used to securely hold the rubber stopper on the container. This prevents the rubber stopper from working loose as internal pressure increases and aspiration vibrates the container. When not in use, the CO_2 extraction system should be disassembled and cleaned to protect rubber parts and plastic tubing from NaOH damage. The NaOH solution may be safely discarded by pouring it into a large volume of water, then allowing the diluted solution to pass through a sanitary sewer system.

To maximize surface contact of air bubbles with the NaOH solutions, thus promoting optimal CO_2 absorption, the ends of the tubing immersed in the solutions are sealed, and the lower 5 cm section of tubing is extensively perforated with a drill bit measuring about 1 mm in diameter. Aspiration of air through the NaOH solution can result in traces of NaOH being carried through the tubing, so the air is passed subsequently through a container of water (replaced daily) to remove trace NaOH.

Exposure of the air supply to aqueous solutions has the potential to saturate the chamber air with water vapor. Because excessive moisture and rapid changes in relative humidity are not desirable for museum objects, a commercially available desiccator (using Drierite absorbent) is inserted at the end of the CO_2 extraction system. The desiccator provides about four hours of humidity control before the desiccant has to be heated and dried out for reuse. Color-indicating silica gel can also be used as a desiccant.

A Fisher Accument portable pH meter (digital display with ± 0.01 pH accuracy) and assorted electrodes (Fisher flat-surface polymer-body combination electrode; Lazar model PHM-146 micro-electrode) were used to measure pH. Water was distilled in the lab and filtered through an Ultrapure (mixed-bed) cartridge which removes silica and CO_2, and usually provides a pH between 6.8 and 7.2. Variation in the pH level in distilled water was initially tested in a 3.8 liter jar with a sealed lid. The lid was modified with intake and outlet valves and a hole for a slit rubber stopper which accommodated passage of the electrode wire. The test was repeated in a specially designed chamber. To ensure safe, uncluttered work areas, appropriate amounts of interconnecting tubing were used to position the CO_2 extraction system outside of the chamber area.

A commercially available glove box can be a suitable chamber if it has provisions for airflow, use of instrumentation, and transfer of materials. A more economical, plexiglass chamber (Fig. 1B), with external dimensions of 61 (L), 46 (W), and 31 (H) cm, was constructed for these tests. Details of the construction of the chamber are shown in Figure 1B–D.

The CO_2 level in the chamber was tested with a National Draeger air sampler and CO_2 detection tubes. These tubes measure percentage of CO_2 (1–30%) per given volume of air (ten strokes of the air sampler) at 20°C.

RESULTS

Preliminary studies, using a 3.8 liter jar, provided a simple method of monitoring pH levels of distilled water. Using a magnetic stirring bar to agitate 100 ml of water and increase the rate of CO_2 absorption from the atmosphere, it was noted that pH rapidly dropped to 5.9 during the first hour. Depending on the ambient temperature, continued stirring can cause the pH eventually to drop to as low as 5.4. In a similar experiment, but incorporating the CO_2 extraction system,

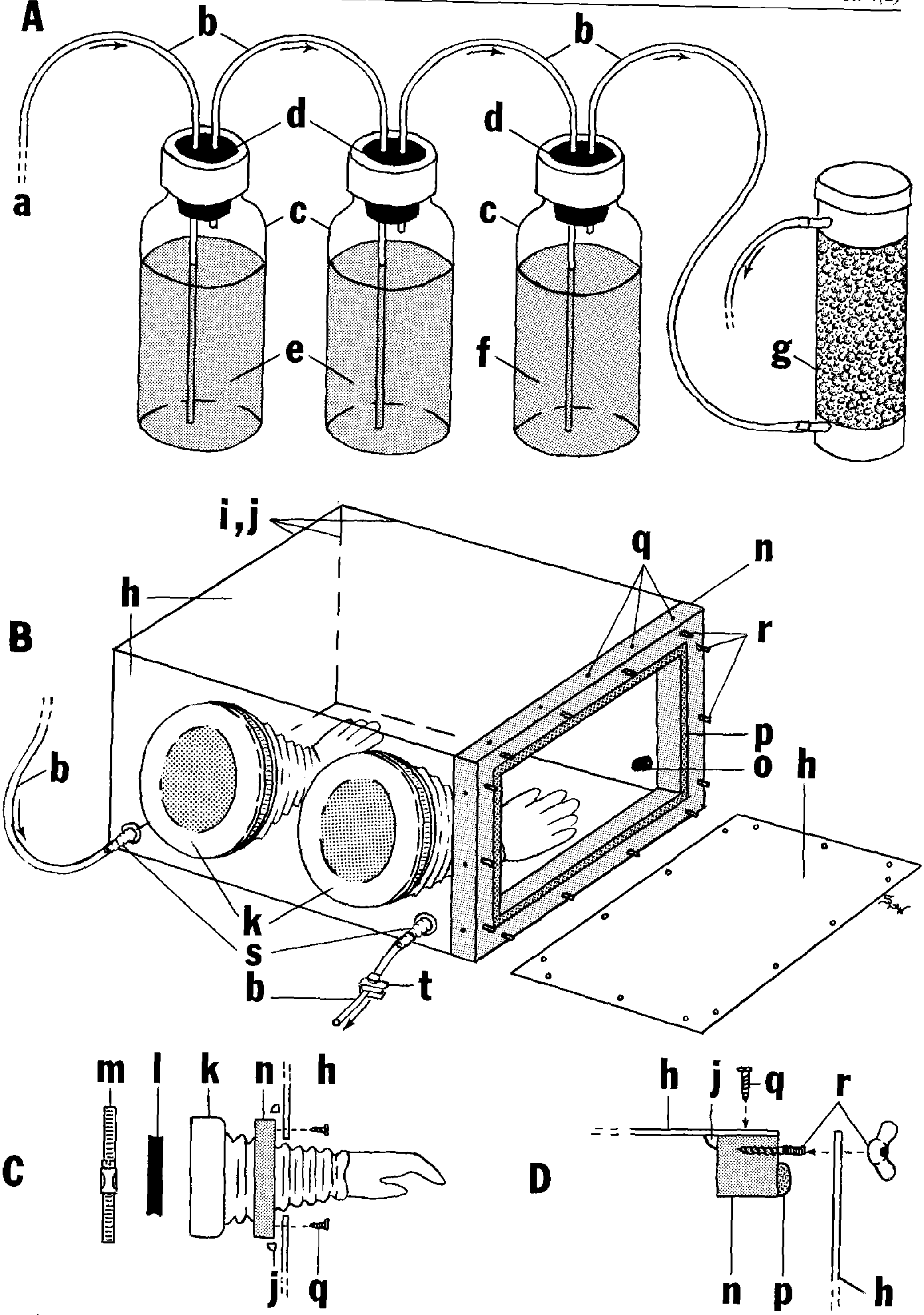

Figure 1. Illustration of the described CO_2 extraction system (A) and chamber (B). Additional detail of the glove assembly (C) and door assembly (D) are illustrated at the bottom. Individual parts are labelled with lower case letters: *a*, air pump (⅙ HP, 1725 RPM, 115 V, 60 Hz, airflow = 37 l/min)

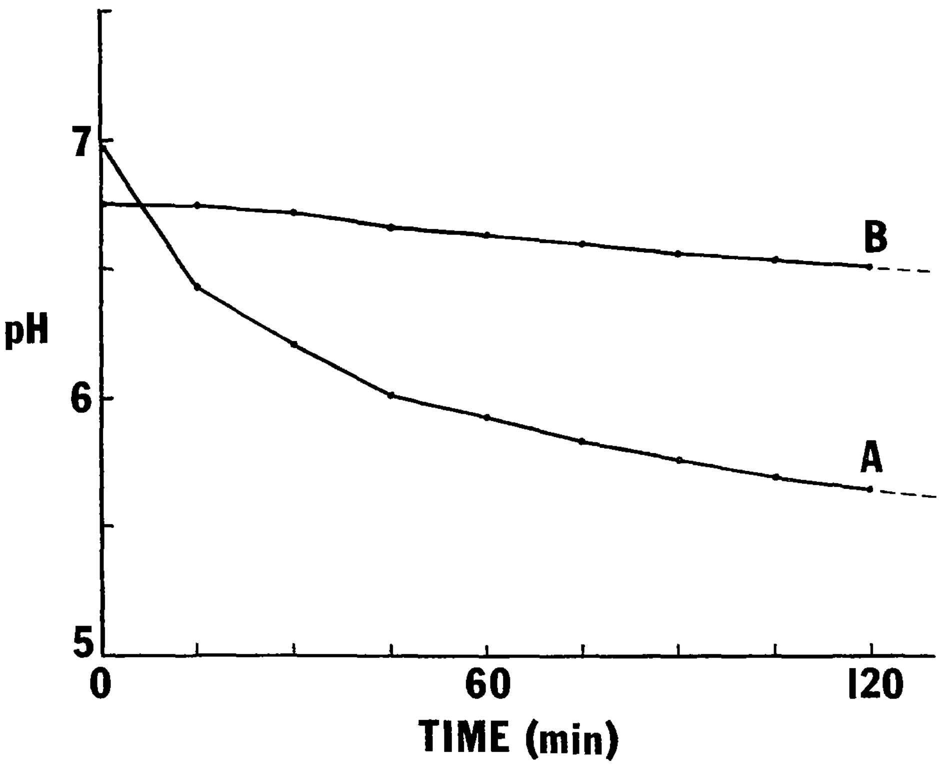

Figure 2. Graph showing the change in pH of water in the presence of atmospheric carbon dioxide (A), and in an environment where the described extraction system has removed most of the CO_2 (B). See text for details.

pH dropped from 6.7 to 6.6 during the first hour. At the end of the second hour the pH was 6.5, indicating the 10N NaOH solution was affecting the CO_2 level in the test jar (Fig. 2). Additional tests were conducted to determine the CO_2 absorption efficiency of different concentrations and quantities of NaOH solution. Higher NaOH concentrations (12N) did not have an appreciably greater effect than the 10N solution. The ability of 1,500 ml of 10N NaOH to absorb CO_2 declined after six hours of use. With further use, efficiency deteriorates and the solution becomes cloudy. To increase longevity and constancy of CO_2 extraction, additional containers of NaOH solution were added to the system. The use of

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or other source of forced air; *b*, ¼-inch plastic tubing; *c*, 2-liter polyethylene containers with 50 mm openings and screw-on caps; *d*, 2-hole, rubber stoppers (size 11); *e*, 10N NaOH solution; *f*, distilled water; *g*, desiccator; *h*, plexiglass (¼-inch thick; front panel with two 15-cm holes cut about 20 cm apart); *i*, plexiglass adhesive; *j*, silicone caulking; *k*, accordian sleeves with gloves; *l*, band of rubber inner tube; *m*, adjustable hose clamp; *n*, particle board (3-cm thick); *o*, solid rubber stopper (size 5; cut lengthwise to accommodate the passage of an electrode or AC electrical wire); *p*, 1 × 3 cm expanded polyethylene sealing strip; *q*, 1-inch screws for metal; *r*, ¼-inch hanger bolts with wing-nuts; *s*, valve assemblies adaptable for ¼-inch plastic tubing; *t*, adjustable tube clamp.

two and three containers of solution provided better control of pH levels for a given time period. Two containers with 1,500 ml of NaOH solution provided over 40 hours of actual operation time. The combined benefits of using NaOH solutions to control CO_2 (effectiveness, longevity, cost, and visual evaluation of solution quality) make this method attractive when compared to commercial alternatives, such as nitrogen-based systems.

After the CO_2 extraction system was tested, it was connected to the chamber. Test results on distilled water in the chamber were similar to those in the test jar. The initial drop in pH in both tests was attributed to residual CO_2 present before total air replacement. To alleviate this problem, the distilled water was stored in a sealed container until sufficient time had elapsed to replace the air in the chamber (15 min at 98.4 ml/sec airflow). Following air replacement, the effectiveness of the apparatus was tested by continuous measurement of pH of a drop of water on a clean microscope slide. After 90 minutes the pH gradually fell from 7.64 to 7.49. The cause of the slight drop in pH is unknown (possibly traces of CO_2 or meter drift), but it is apparent that the apparatus was minimizing the influence of atmospheric CO_2 on pH readings.

To document CO_2 levels in the chamber during operation, National Draeger sampling tubes were used. The CO_2 was initially recorded at 0.04%—the same as expected atmospheric CO_2 concentrations. After 15 min the CO_2 concentration in the chamber was 0.02%. Detectable CO_2 concentrations in air samples taken at 30, 45, and 60 minutes were recorded at 0.01% or less, thus indicating over 75% of the atmospheric CO_2 was extracted.

Discussion

The accuracy of pH measurements in the described apparatus depends on proper use and care of the pH meter and electrode. The electrode must be clean and free from encrusted chemicals, air bubbles, and electrical charge, and filled with the appropriate electrolyte solution. The pH meter should be calibrated using buffers representing extremes of the anticipated pH range to be measured, and adjusted if temperatures are different than the standard used for the buffer. It is also necessary to understand the nature of the material being analyzed. For instance, it is virtually impossible to get pH values of ultra-pure water samples; the readings on the pH meter will drift. Also, it is important to realize that determination of pH of material surfaces can include variations attributable to contaminants. For additional information about pH determination, Westcott (1978) is a useful reference.

The problems of using pH equipment where CO_2 can interfere with readings have been discussed. The described chamber has proven effective in controlling the development of carbonic acid in water used for pH determination. Because it is likely that residual CO_2 in the chamber may affect the pH of the water, it is critical to enclose the water supply until the air has been exchanged with treated air. It is also recommended to keep the water sealed in a polyethylene container when not in use because of the possible existence of minute traces of CO_2 that may affect the pH of the water over time.

The time required for replacing the air in the chamber is dependent on the rate of airflow. To expedite the replacement process, airflow can be increased during the initial stages of the operation. For the described chamber, a maximum airflow of about 100 ml/sec was adequate for exchanging the air in a 15 min time period. Afterward, airflow can be reduced by about one-third as long as a positive pressure is maintained in the chamber. A slower airflow through the CO_2 extraction system will promote longer efficacy of the NaOH solutions and desiccator. However, with lower positive pressure in the chamber it is easier to cause pressure fluctuations with movement of the gloves and sleeves.

The chamber described is intended to accommodate relatively small objects. For the sake of efficiency, it is convenient to be able to do pH measurements on several objects before the chamber is opened and the air exchange procedure is repeated. To accommodate extra objects and to protect them from possible spillage of fluids, a small shelf system can be added inside the chamber.

The chamber can accommodate oversized objects by removing the side panel and inserting the part of the object to be analyzed. The rest of the object may be enclosed in a large plastic bag which should be sealed around the outside of the chamber. The resulting increase in chamber volume will require a longer air-exchange time, but should have no other effect on pH measurement as long as positive pressure is maintained on the inside of the chamber.

Acknowledgments

The chamber for this project was constructed in the Section of Exhibits, The Carnegie Museum of Natural History. I extend my appreciation to Stephen Weber (Department of Chemistry, University of Pittsburgh) for making suggestions regarding the CO_2 extraction system and for reviewing the manuscript, to Robert Waller (National Museums of Natural Sciences, Canada) for useful suggestions, and to Elizabeth Walsh (The Carnegie Museum of Natural History) for assisting with the testing of the apparatus and for reviewing the manuscript. Support for this project was received from The Pittsburgh Foundation, Fisher Scientific, and the National Museum Act (FM-407952) administered by the Smithsonian Institution.

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DOCUMENTATION GUIDELINES FOR THE PREPARATION AND CONSERVATION OF PALEONTOLOGICAL AND GEOLOGICAL SPECIMENS

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Abstract.—The importance of complete and accurate documentation of preparation and conservation treatments cannot be over-emphasized. Accordingly, the Conservation Committee of the Society for the Preservation of Natural History Collections has undertaken the development of guidelines for the documentation of specimen condition and treatments employed in natural science collections. The guidelines and examples of formats for documenting paleontological and geological specimens are presented.

PREFACE

During the past two years, the Society for the Preservation of Natural History Collections (SPNHC) Conservation Committee has undertaken several projects to increase conservation awareness and promote professional practices for the preservation of natural science collections. One important project has been to formulate documentation guidelines for recording specimen condition and treatment methods.

The following guidelines for paleontological and geological specimens were adopted as a working document by the Conservation Committee in May and by the SPNHC Council in August, 1988. The guidelines were developed by Gerald R. Fitzgerald, based on his work at the Paleobiology Division, National Museum of Natural Sciences (NMNS), National Museums of Canada (NMC) and discussions and correspondence with professionals in the United States, Canada, the United Kingdom, and Ireland. Similar guidelines for life science specimens are currently being drafted by Kimball Garrett at the Los Angeles County Museum of Natural History. We hope that you will incorporate such documentation practices into your work. The guidelines published herein will be revised and improved as these recommendations are tested. Please send comments and suggestions to G. R. Fitzgerald.

C. L. Rose, Chairman
SPNHC Conservation Committee

DOCUMENTATION GUIDELINES FOR THE PREPARATION AND CONSERVATION OF PALEONTOLOGICAL AND GEOLOGICAL SPECIMENS

Introduction

The need for good records of all treatments to which an object is subjected is recognized by conservators to be an essential part of the object's documentation. Records provide information that is essential in determining the effectiveness of past treatments and will enable scientists to determine easily if there have been previous treatments which will affect the validity of any analytical investigation. To be useful the information must be complete so that future workers will be certain of the specimen's history. The days of research based solely on gross morphology and preparation aimed at saving only these details have passed. Modern research and conservation are now more complex, and accurate information is required to make rational decisions.

Within the natural sciences, an awareness of the need for such information is

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just developing. Some institutions have kept treatment records but generally they are incomplete and therefore of limited value. Institutions are therefore encouraged to adopt standards of preparation and conservation documentation that will provide the basis for collections' care and research.

Minimum Documentation Requirements

Documentation of specimen treatments starts at the time of collection and provides a continuous history. Each time a specimen receives treatment, is loaned, or put on display a condition/treatment report should be completed. This should record the specimen's condition before and after treatment, techniques and equipment used, as well as materials and chemicals employed in contact with the specimen. It is important that any variations from standard procedures are carefully documented and that any observed effects such as change in colour, cracking, or spalling of the surface are recorded.

Guidance for Complete Documentation

1.0 *Field collection and shipping.*—The future course of treatment of fossils, minerals and rocks is often determined by their geological provenience. Records should begin with the methods used for their collection (including all field treatments), packing, and transportation. This information should be recorded in the field notes and cross referenced or appended to the condition/treatment report.

2.0 *Laboratory treatment reports.*—In the laboratory, preparation and conservation processes are often complex and require detailed documentation. A complete report will include many of the following types of information.

2.1 *General information.*—Reports should be clearly identified by specimen catalogue number or field number. It is not necessary to duplicate all the catalogue information but basic data such as provenience and type of specimen may be useful fields on which to search if files are computerized.

2.2 *Treatment authorization.*—This should include a description of the authorized work, the reason for treatment, the signature of the person responsible for the specimen, and the date.

2.3 *Specimen condition.*—Reports should include both before and after treatment details of specimen condition. Information could include: general condition, missing parts, breaks, cracks, deterioration, adhering matrix, type of fossilization, corrosion, patina, dirt, mould, and evidence of previous unrecorded treatments with comments on possible techniques and materials. Attention should be given to documenting conditions that may affect the stability of the specimen. Conditions reports are often best supplemented with a sketch or photograph.

These reports are necessary to monitor long-term stability of collections and in time will provide a good information base. Records will be limited to specimens which have received treatment and therefore may not be a representative sample of a collection. To better monitor a collection as a whole, condition reports could be prepared for selected specimens representing various specimen types and proveniences.

2.4 *Matrix removal and surface cleaning.*—Techniques and chemicals used to develop or clean specimens can modify their surfaces and/or internal structure, possibly resulting in long-term conservation problems. This information, along with other technical data such as type of air abrasive powder, air pressure, power levels, and solution concentrations, is important for their future analysis and interpretation. Notes should be made on matrix type, any other materials removed from a specimen, the area where work was done, and matrix or specimen samples that may have been set aside for future analysis.

2.5 *Consolidants, adhesives, and infills.*—These procedures involve the addition of a material to a specimen. The material, with specific reference to brand name, composition, manufacturer, batch number, concentration, solvents, additives, separation barriers, method of application, and the part of the specimen where work was done, should be recorded.

2.6 *Moulding and casting.*—Moulding processes may result in significant changes to a specimen. All materials that come into contact with a specimen or have the potential of doing so should be recorded. Reports should also include details of premoulding preparation, post-moulding cleaning or repairs, and observed effects on specimens.

2.7 *Collections personnel undertaking examination or treatment of specimens.*—Individuals who prepare condition reports and/or perform treatments on specimens should be clearly identified. The date that the work is undertaken also is very important for future reference and treatment studies.

2.8 *Additional information.*—Detailed records should be kept of sampling or analytical testing of specimens. Ongoing records of climatic conditions and fumigation in storage and/or display areas also are important. Other types of information could include notes on specialized supports, recommended storage or display conditions, details of displays and loans, and reference to papers or persons providing advice on treatments. All photographs taken should be listed and cross referenced to their storage location.

Implementation

There are many ways of documenting treatments. Methods and format depend on the resources of the institution, the type of collection and the laboratory techniques used. What is important is that keeping accurate and complete treatment records should become a normal laboratory procedure so that information is not lost.

To simplify the recording process, conservation/treatment forms can be developed that incorporate a checklist referring to standardized techniques. Complete descriptions of these techniques should be maintained with the conservation files and any modifications or variations must be carefully documented including the date when changes were introduced. If the form is well designed it could simplify future computerization of records. When identical treatments are used on a suite of specimens from the same site, procedures can be documented in detail and cross referenced to individual specimens. Establishing separate files which detail the composition, manufacturer, etc. of materials and chemicals will help to speed up record keeping.

Discussion

The guidelines provide direction as to what types of information should be recorded and possible methods of implementation. At the present time, most institutions will use a manual system; even if a computer is available, it is probably better to use a manual system for some time to ensure that fields are properly established before embarking on computerization. Forms developed at the Paleo-

(*Discussion, cont. p. 44*)

Page 1 of 1

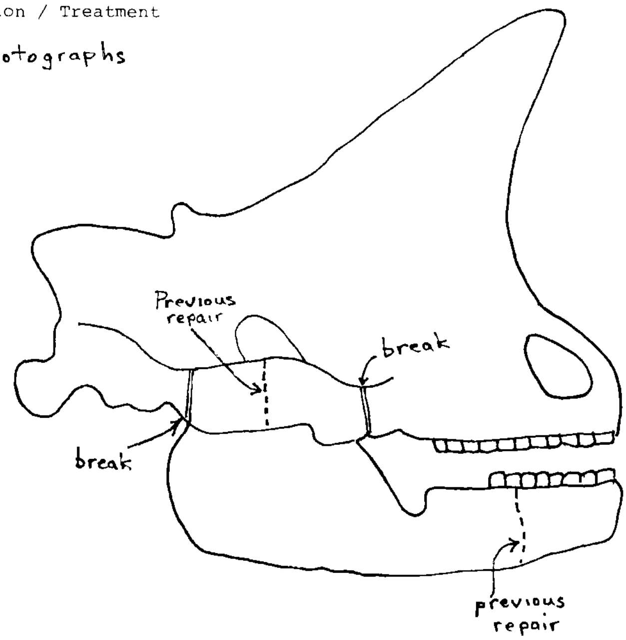
CONSERVATION/PREPARATION RECORD

SPECIMEN NO: NMC 8183
Part of Specimen: Skull - cast
O Original or ⊗ Subsequent conservation/preparation
Date Started: Aug 17, 1987 Date Completed: Nov 2, 1987 Hours Spent: 15

Conservator/Preparator: K.M. Shepherd Assistant:

Specimen Condition / Treatment

See photographs



Matrix Removal

O Manual	O Air scribe
O Hand grinder	O Air abrasive with ________
O Cavitron	Air pressure ________
O ________	O Acid - type ________
	- concentration ____

Surface Cleaning

⊗ Dry Brush	O Water
O Cavitron	O Solvent
* ⊗ Compressed Air 50 psi	O Ultrasonic bath in ________
O Air abrasive with ____	O ________
Air pressure ________	

* 50 cm from specimen

Figure 1. The "Conservation/Preparation Record" form developed at the Paleobiology Division, NMNS, NMC, (8½″ × 14″) *A*. Front; *B*. Back. Note adequate space for notes and sketches. Simple procedures can be recorded by checking appropriate treatments. Additional information is recorded on supplementary sheets and appended to the form. A file is maintained for each treated specimen. In this case, a treatment authorization section was not included because much of the responsibility

Consolidation

Consolidant ⊗ VINAC B15in ethanol ○ PVA Emulsion
○ Acryloid B72 in ______ ○ ______

Application Method ○ Brush ○ Dip
⊗ Pipet. 10+ applications ○ Vacuum Impregnation
○ Injection

Area of Consolidation - region of break

Adhesive

○ Acryloid B72 in ______ ○ PVA Emulsion
* ⊗ Epoxy Resin ○ VINAC B15 in ______
○ Polyester Resin ○ ______

* Lepages 5 minute two part epoxy

Infill

⊗ Plaster of Paris ○ Polyester Resin
○ Epoxy Putty ○ Epoxy Resin
○ Paper Maché ○ ______

○ Separating Barrier ______
○ Filler ______
⊗ Colourant Reeves tempra - Yellow Ochre
○ Surface Finish ______

Location of Infill

Supporting Base

Padding ○ Ethafoam ○ Bubble pack
○ Polyethylene ○ Paper towels
○ Acid Free Tissue ○ ______

Support ○ Plaster/burlap ○ Polyurethane Foam
○ Paper Maché ○ Corex/ethafoam
○ ______

Dust Cover ○ Polyethylene ___ mil ○ ______
○ Tyvek

Photographs

Negative No: C 87-009
Slide No:

References/Advisors

(*Figure 1, cont.*) for collection care and treatment is routinely delegated to the conservation/preparation staff. When questions arise they are easily resolved by direct discussion with curators. Note, however, that both the conservator or preparator and assistant are listed as being the individuals responsible for the treatment undertaken. In addition, the time spent on each specimen is recorded. This information can provide useful statistics in justifying resources needed for various projects.

CONSERVATION RECORD/MOULDING

SPECIMEN NO: 11782
Part of Specimen: horncore up to burr
Date Started: Mar 14, 1988 Date Completed: Mar 21/88 Hours Spent:

Conservator/Preparator: G. R. Fitzgerald Assistant

(X) Pre treatment on Conservation/Preparation Record Form

Separator on Specimen
- (X) VINAC B15 in 85% ethanol 15% methanol
- ( ) Vaseline
- ( ) Parting Agent #10
- ( ) Acryloid B72 in ____
- ( ) Silicone Spray ____
- ( ) Paraffin Wax
- ( ) ____

Dykes and Infills — one piece mould
- ( ) Modeling Clay
- ( ) Water Clay
- ( ) Paraffin Wax
- ( ) Silicone Modeling Clay
- ( ) ____

Mould Material
- (X) Latex
- ( ) Plaster
- ( ) Modeling Clay
- ( ) ____
- ( ) Silicone
- ( ) Vinamold
- ( ) Jeltrate

LE Latex + cheesecloth - 2 layers

Separator between Mould & Mother Mould
- ( ) Aluminum Foil & Masking Tape
- ( ) Parting Agent #10
- ( ) ____

Mother Mould
- ( ) Polyester Resin
- ( ) Plaster of Paris
- (X) Coecol (dental plaster) and fiberglass strand
  - 2 pieces – plasticene dyke + vaseline separator on plaster

Observed Effects on Specimen

none

( ) Post treatment on Conservation/Preparation Record Form

Photographs

Negative No: C 88 - 006
Slide No:

Figure 2. "Conservation Record/Moulding" form used at the Paleobiology Division, NMNS, NMC. Treatments that are done to prepare a specimen for moulding and repairs or cleaning afterwards are recorded on "Conservation/Preparation Record" forms. Together, they provide a complete record of the entire procedure.

GEOLOGICAL CONSERVATION DOCUMENTATION FORM

sheet no._____.

[ACCN. NO][STORE LOCALITY][OWNER][LAB. NO]

DESCRIPTION
SPECIMEN [
SUBSTRATE[

CONDITION REPORT DATE [ ]
SPECIMEN CONDITION [
[
SUBSTRATE CONDITION [
[
ENV. MON. [ ][RH][TEMP][LIGHT
ENV. CON. [
STORAGE [
PREVIOUS CONSERVATION WORK[
[

[DIAGRAM]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]
PRE CONSERVATION PHOTOGRAPH [ ]

TREATMENT ORDER

[ORDER][	TREATMENT METHOD][	TIME][	PHOTO/XRAY][	WORKER/DATE]
[01][	][	][	][	]
[02][	][	][	][	]
[03][	][	][	][	]
[04][	][	][	][	]
[05][	][	][	][	]
[06][	][	][	][	]
[07][	][	][	][	]
[08][	][	][	][	]

MOULDING
MATERIAL [ ]
SEPARATOR [ ]
FILLER [ ]
WALLS [ ]

RECOMMENDATIONS
ENV. CONTROL [RH][TEMP][LIGHT]
[ ]
STORAGE/PACKAGING [ ]
[ ]
CONSERVATOR [ ][OTHER WORKERS]
DATE WORK FINISHED [ ]DATE WORK RETURNED [ ]

Figure 3. "Geological Conservation Documentation Form" developed and used at the Leicestershire Museums, Art Galleries and Records Service and the City of Bristol Museum and Art Gallery. It is printed on both sides of a standard card (approximately 8¼″ × 11⅝″). *A.* Front; *B.* Back.

(*Discussion, continued*)

biology Division, NMNS, NMC (Figs. 1A, B; 2), and another developed jointly by Leicestershire County Museum, Art Galleries and Records Service and the City of Bristol Museum and Art Gallery (Fig. 3A, B) are provided as examples to help individual institutions develop a system tailored to their own needs.

Detailed treatment records form as important a part of a specimen's documentation as provenience and collector. As museum professionals and scientists, we must address this issue so that we will be able to give the specimens in our charge the best possible care.

SPECIMEN PREPARATION AND CLEANING

TECHNIQUE [ ]
[ ]
[ ]
MATERIALS [ ]
[ ]
[ ]
POWER [ ]
[ ]
SUPPORT [ ]
[ ]
OTHER PROCEDURES [ ]
[ ]

[DIAGRAM]
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TREATMENTS OF SPECIMEN/SUBSTRATE

CONSOLIDANT [ ][APPLIED BY :]
SOLVENT [ ]
STRENGTH [ ]
ADHESIVE [ ][APPLIED BY :]
FILLER(SEP) [ ]
CHEMICAL TREATMENTS [ ]
[ ]

[DIAGRAM]
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COMPUTERIZED SPECIMEN AND PREPARATION/CONSERVATION WORKSHEETS FOR FOSSIL VERTEBRATES

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Abstract.—Two worksheets have been developed in order to store and retrieve specimen and preparation/conservation information for fossil vertebrates on the Canadian Heritage Information Network PARIS system. All information is first entered from these worksheets into a microcomputer; after editing, the data are uploaded to CHIN. Most information recorded is rigidly standardized, enabling rapid retrieval. The use of free-form remarks fields encourages the retention of nonstandardized information.

Standardized data collection is an essential component of a properly curated collection. In order to achieve this goal, two worksheets have been devised at the Royal Ontario Museum (ROM) for the storage and retrieval of fossil vertebrate specimen and preparation/conservation information on the PARIS system of the Canadian Heritage Information Network (CHIN). This paper outlines the method used to handle such information.

COMPUTERIZATION SYSTEM

Features of CHIN in Ottawa

The CHIN PARIS mainframe computer (Control Data Cyber 180/835) located in Ottawa, Ontario, has 7 gigabytes of disk storage. This huge amount is necessary because the PARIS system already has more than three million records entered by 42 different clients; of these records, approximately 700,000 represent 18 natural science departments situated across Canada (Cox, 1986). It also enables each client department to avoid what McLaren *et al.* (1986) noted to be the greatest liability for users of only microcomputers, that is, lack of computer disk space.

Two other major features of CHIN include their accessible staff of hardware and software specialists and their development of nationally accepted standards and procedures (see Delroy *et al.*, 1985). These tangible assets obviate the necessity for all museum personnel to become computer experts, thus enabling them to spend more time with their collections.

Advantages to the ROM in Toronto

The link with the mainframe computer is made via a Cybernex dumb terminal. This provides users with powerful search and retrieval capabilities without the need for intermediary computer operators. Rapid searches can be made for information in any field or combination of fields, especially if the data are standardized. See Holm (1986) for records management methods of another department using this system.

Entry and editing of records while on-line with the CHIN mainframe can be slow due to the number of users using the system at any one time. Many departments of the ROM therefore use a microcomputer, utilising database management software (such as DBASE) for more efficient data entry and editing. Edited data are then uploaded to CHIN. Subsequently, subsets of data can be downloaded from the mainframe to a ROM microcomputer for further editing, printing of reports, cards and labels, or other records management functions (e.g., see McLaren *et al.,* 1987). This arrangement takes advantage of the flexibility of the microcomputer when manipulating small batches of data as well as the power of the CHIN mainframe when searching the whole database. For description of another hybrid system see Folse *et al.* (1987).

Developments at the Department of Vertebrate Paleontology, ROM

Two worksheets have been developed: one for specimen information, subdivided into 7 sections (Fig. 1) and one for preparation/conservation information, subdivided into 3 sections (Fig. 2). This means that there are two worksheets for any one specimen. Although the worksheets are stored in separate locations, all information for any one specimen is united via microcomputer and uploaded to CHIN to produce only one complete record for each specimen. Theoretically, there may be several conservation reports per specimen which may be all linked into one record. However, the details of this more complex type of record have not yet been worked out.

Each worksheet is only one page long to ensure ease of use. These worksheets have evolved considerably since their inception in 1983 (1986 for the preparation/conservation worksheet). In original form both were multi-page documents. It was found that these were cumbersome and that the single page format presented here was preferable.

Each worksheet contains the most commonly used fields with their respective CHIN field mnemonics. This facilitates entry of data onto a computer. At this point, some fields are not yet in general use; consequently, the information is entered into a "local use" field (e.g., volume of mold on the conservation worksheet is entered into our local use field number 5, see Fig. 2). Regardless, most fields are rigidly standardized for ease of search and retrieval. Guidelines for this standardization are published in Delroy *et al.* (1985). Seymour (1986) gives standardization details for the specimen nature (SPENA) field for fossil vertebrates on the ROM database. It should be noted here that since the publication of Seymour (1986), CHIN has decided that SPENA should be completely standardized in a way which is not fully compatible with Seymour's system. This does not deny the usefulness of the proposed system; however, all information that is presently stored in SPENA in the vertebrate fossil database will ultimately be transferred to another field. Because of the large amount of space available on the mainframe and as cards and labels are printed from the same database, the vertebrate fossil database does not codify any information as suggested by Black (1973).

An important feature of the PARIS system is the concept of the remarks field. Remarks fields are associated with most major sections and allow as well as encourage the recording and the retention of non-standard information. Although most information is easily standardized, it was found that there was a consistent need to record comments and information of a diverse nature. It is tedious and often impossible to standardize this type of information. More importantly, if this sort of information will rarely be searched for, then there is little need to

SPECIMEN WORKSHEET - VERT. PALEO., ROM — Par#

(CL) Mammalia (ORD) Carnivora (FAM) Felidae
(GEN) Panthera (SP) leo Subsp(SSP) atrox
(SPECNM) (SEX)
Authority(GENA/D) Authority(SPA/D)
Former(GENF) Felis Former(SPF) atrox Type(TYP) holotype
Name(TYPNM) Felis atrox Authority(TYPA) Leidy 1853

CAT.NO.(TOR/CN/I) 26323 Other(OCN) ANSP 12546 Previous(PN)
Field No.(FLN) Acc. No.(AN) Loc.No.(LOCN)
Cataloguer(CAT) Seymour, K. Cat. Date(CD) 19880223
Mode of Acquisition(MO) cast Date(AQD) 19880200

SPEC. NATURE (SPENA) mandible partial; incomplete; tooth; LP3-4; LM1; complete; LC; incomplete; left; cast; 2; +
Spec. remarks(SPEREM) canine separate from mandible
Assoc. Spec.(SPEAA) ANSP 11495 Equus LM; ANSP 13008 Bison LM
Location(PLRM) Collections (PLU) systematic (CLRM)
Identifier(IDR) Leidy, Joseph Date(IDD) 18530000
Identifier remarks(IDREM)
Identifier references(IDRF)
Publication(PUB) Leidy, J. 1853. Trans. Amer. Philosophical Soc. 10: 319-321 (ILN) Pl. 34, Figs 1-2

COLLECTOR (MCOL) Huntington, W.H.; + Date(CPDA) 18360401 P
Collec. Method(CPM)
Collec. Remarks(CPREM) assumed to be collector; donated fossil to APS
Preparator(PR) Date Prepared(DPR)
Preparation(PRT)

SOURCE (SR) Academy of Natural Sciences
Address(SRMAD) 19th and the Parkway
City(SRMUN) Philadelphia Prov/state(SRPR) Pennsylvania
Country(SRCRY) U.S.A. Postal code(SRPC) 19103
Telephone(SRTEL) (215) 299-1133
Source remarks(SRREM)

CONTINENT (ORCT) North America Country(ORCRY) U.S.A.
Prov/state(ORPR) Mississippi County(ORCY) Adams
Location name(LOCNM) Natchez Site name(ZNA)
Loc. Descr.(LOCDE) approx 6 miles north of Natchez
Waterbody(WB)
Loc. remarks(LOCREM)
Map ref.(MPR/OMPR)
(LAT) 314000 Dir(LTD) N (LNG) 0912500 Dir(LGD) W
Military Map Ref.(UTMZ) (UTME) (UTMN)
Sec.(ORSC) Twp(ORTP) 7; 8 Range(ORRG) 3; W
Concession/lot(ORCLT)

GEOL. PERIOD (DTPER) Quaternary Geol. age(DTGEO) Pleistocene; upper
Stage(BIO) Rancholabrean
Lithostrat. Info.(STL)

Strat. remarks(STREM)

PREPARATION/CONSERVATION WORKSHEET - VERT. PALEO., ROM Sheet No. 1

A. SPECIMEN INFORMATION

CL/ORD Carnivora (FAM) Felidae (GEN) Panthera

Cat. # (CN) 26323 Other # (OCN) ANSP 12546 Field # (FLN) ____ Acc. # (AN) ____

Specimen nature(SPENA) mandible partial; incomplete; tooth; LP3-4; LM1; complete; LC; incomplete; left

Condition remarks(KCREM) Bone very crumbly; ironstone encrustation holding specimen together.

B. PREPARATION/CONSERVATION

Preparator(PR) May, P. Prep Start(DPRS) 19880310 Prep Finish(DPRF) 19880311

Prep. Tools(PRT) (a) manual (b) grinder c.cavitron d.airscribe e.vibrotool f.water g.ultrasonic bath h.air abrasive with ____ i.acid ____ (j) solvent ethanol

Adhesive(KFMT) UHU Consolidant(KFMT) Vinac in ethanol

Consolidant applicator (a) brush b.dropper c. injection (d) vacuum impregnation

Area of Consolidation(KFMT) Entire

Filler(KOT) ____ Location(KOT) ____

Specimen Support(KOT) ____

Sediment sample?(DI1) 4 Thin section?(TSN) ____ Photo?(PHN) 4

X-Ray Data(RXRD) ____

Experimental treatment(EXPT) trace element analysis done on sediment samples

Preparation treatment comments (KREM) large piece of encrusting ironstone removed exposing mandibular bone; this piece saved with specimen. mold of mandibular surface taken

C. REPLICAS MOLDING

Mold preparator(MDM) Leitch, A. Molding Date(MDD) 19880216

Parts of Specimen Molded(MDSP) mandible

Molding Compound(MOMA) RTV 700; Beta 2 catalyst Mold Type(MDT) 2 piece

Mother Mold(LU1) WEP

Dike Material(LU2) Klean Klay Separator(s)(LU4) Vinac

Quantity of Molds(MDQTY) 1 Mold Location(MDPLBS) collections

Mold Condition(MDKPC) excellent Volume of Mold(LU5) 200 ml

Molding Remarks/Effects on Specimen(MDREM) mold has plug with 4 risers in canine alveolus

CASTING (CAST)

	Quantity	Date	Location of replica	Casting material	Preparator
1	4	19880300	ROM collections	WEP	Dickson, M.
2	1	19880400	Philadelphia	WEP	Dickson, M.
3					

Figure 2. Sample Preparation/Conservation Worksheet. All CHIN codes (in brackets) are explained in Delroy *et al.* (1985), except for the codes in the molding and casting section which will be detailed in a future revised CHIN data dictionary.

←

Figure 1. Sample Specimen Worksheet. All CHIN codes (in brackets) are explained in Delroy *et al.* (1985).

standardize. This does not imply that the information is not important, and just keeping it associated with the specimen record is almost always sufficient.

Preparation/Conservation Worksheet

Besides its function in the recording of data, this worksheet is used to train new staff in departmental procedures and to evaluate conservation treatments as well as preparation and molding techniques. In the past any such evaluations have relied on people's memories because this information was not usually recorded, as Fitzgerald (1988) emphasized. Now, not only is most information standardized but it is stored in association with the usual specimen information to provide a complete documentation package. It is hoped that this new approach will facilitate future work and research in these areas.

Acknowledgments

I would like to thank Andrew Leitch for his major contributions to the preparation/conservation worksheet; without him it would not have been developed and effectively implemented. I would also like to thank Maggie Dickson who gave advice concerning the molding section of the preparation/conservation worksheet as well as the many people who have made suggestions over the years for improving the worksheets, especially Jackie Heath, Pierre Lacasse, Mary Ronback and Deirdre Breton. Two anonymous reviewers also made helpful comments which improved the manuscript.

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REVIEW OF ORGANIZATIONS AND RESOURCES THAT SERVE THE NEEDS OF NATURAL HISTORY COLLECTIONS

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Abstract.—Collection management practices have traditionally been learned and transmitted by on-the-job training and oral instruction. However, this system leads to a number of problems including repeatedly "reinventing the wheel" and reinforcement of inappropriate, even destructive, collection practices. In order to correct this situation, a professional structure must exist for transmitting knowledge, for encouraging the development of new knowledge, and for critically reviewing results of research. Such a structure should include professional societies, support organizations, and a body of literature. This paper summarizes the extent of the professional structure which serves the needs of professionals who manage natural history collections.

Natural history collections historically have been managed according to techniques transmitted during the training of systematists within each natural history discipline. The contents of these collections form the basis for much of the research performed by these scientists, and it has long been recognized that proper care of the specimens and their data is essential to ensure their value to research (Grinnell, 1910). However, specimens in collections too often are considered only tools, and their preservation and care given minimal attention. The result can be the permanent loss of data or even specimens, and a waste of a potentially valuable resource. In spite of the fact that curatorial positions are usually filled by systematists, training in curatorial and conservation techniques is not considered a requirement in academic systematics programs. A recent pamphlet entitled "Careers in Biological Systematics" does not even mention curatorial care in the section, "What training is required to become a systematist?" (American Society of Plant Taxonomists-Society of Systematic Zoologists, 1986). In practice, the care of natural history collections is handled increasingly by the growing profession of collection managers, individuals trained primarily in the care and conservation of collections.

Recently, there has been a reaffirmation throughout the museum community that "museum collections, in the aggregate, represent the whole diversity of the world's cultural, scientific and natural heritage" (American Association of Museums, 1984). It is the aggregate significance of the collections that must be considered, and the value of each collection is enhanced by its role as a component of our total heritage. If this value is to be realized to the greatest extent possible, it is imperative that appropriate preservation and management techniques be used to care for specimens. Professionals who subscribe to this philosophy realize that specimen care and management can no longer be given second and third priorities. Instead, every effort must be made to be certain that our present management techniques are appropriate and are not detrimental to the specimens, that research is encouraged to determine new and better methods for specimen care, and that dissemination of this information is facilitated. A professional structure must exist if these goals are to be accomplished. This paper summarizes a review

Collection Forum, 4(2), 1988, pp. 51–64

performed to determine the extent of the professional structure which currently serves the needs of professionals directly responsible for managing natural history collections in North America, with an emphasis on vertebrate collections.

Professional Societies

Societies Within Natural History Disciplines

Natural history collections are served to varying degrees by two types of professional societies: those representing members of natural history disciplines, and those representing the museum profession. Societies within the first group are numerous with goals which reflect the needs and interests of the specific field. The societies vary with respect to the academic field they serve, the geographic scope of their members, and their relationship with collections. The natural history fields with a history of collection-based research can be subdivided into twelve general categories: anthropology, archaeology, botany, entomology, geology, herpetology, ichthyology, invertebrates, mammalogy, microbiology, ornithology, and paleontology.

Only a small percentage of the natural history professional societies are directly concerned with collections. The 1986 Membership Directory of the Society for the Preservation of Natural History Collections (SPNHC) lists over 125 societies dealing with the natural sciences to which individual SPNHC members belong. However, out of the 28 societies which deal with studies of vertebrates, only four exhibit strong interests in collections. These are the American Society of Mammalogists (ASM), the American Ornithologists' Union (AOU), the American Society of Ichthyologists and Herpetologists (ASIH), and the Society for the Study of Amphibians and Reptiles (SSAR).

The collection orientation of ASM, AOU, ASIH, and SSAR is exhibited by the existence of systematics collections committees and/or information retrieval committees. These committees serve as a focal point for discussion concerning collection needs ranging from questions of ethics and philosophy to data field definitions for information retrieval purposes (for example, Ad Hoc Committee to Evaluate Standing Committees, 1987). The level of collection-oriented activity varies both among societies and from year to year, depending greatly on the individuals involved with the committees. Some committees sponsor workshops or poster sessions at annual meetings (for example, ASM Information Retrieval Committee, "Computers and Museums," 1987 annual meeting, Albuquerque, NM) and/or projects which may result in publications (for example, Fink *et al.*, 1977; Williams *et al.*, 1979b). "Curation Newsletter" is published through ASIH but appears irregularly.

Members of the standing and Ad Hoc committees in the natural history professional societies have been responsible for the initial documentation of the nature, extent, and in some cases, the condition and needs of North American systematics collections. They have responded as well to specific requests by U.S. Federal agencies to develop professional policies for field methods and the handling of live animals. Table 1 summarizes the reports which relate to or have some bearing on the management of natural history collections and is based, in part, on a list developed by Steussy and Thomson (1981).

The committees serve both as sources of information and as mechanisms to encourage proper care and maintenance of specimens within collections. They are

Table 1. Reports on systematics resources and concerns relevant to the management of natural history collections (updated from Struessy and Thompson, 1981).

Botany
- Advisory Committee for Systematics Resources, 1974, 1979
- Croat, 1978
- Nevling, 1973

Entomology and arachnology
- Hurd et al., 1974, 1975
- Levy, 1970
- Randolph, 1974

Herpetology
- ASIH, HL, and SSAR, 1987
- Leviton et al., 1982
- Leviton et al., 1985
- Wake et al., 1975a, b

Ichthyology
- ASIH, AFS, and AIFRB, 1987
- Collette and Lachner, 1976
- Fink et al., 1977
- Lachner et al., 1976

Invertebrate zoology
- Lee, 1978
- Joint Committee on Systematic Resources in Invertebrate Zoology, 1979a, b

Malacology
- Solem, 1975
- Thompson, 1982, 1985

Mammalogy
- *Ad Hoc* Committee on Acceptable Field Methods . . . , 1987
- Anderson, 1976
- Anderson et al., 1974
- Choate, 1978
- Choate and Genoways, 1975
- Committee on Information Retrieval, 1985
- Williams, Smolen and Brigida, 1979
- Yates, Barbor and Armstrong, 1987

Ornithology
- *Ad Hoc* Committee on the Use of Wild Birds in Research, 1988
- Aldrich et al., 1975
- Banks, Clench and Barlow, 1973
- Clench, Banks and Barlow, 1976
- King and Bock, 1978
- King et al., 1977

Paleontology
- Glenister et al., 1976
- Langston et al., 1972, 1977

particularly important as links between the needs of the users and the needs of the specimens. However, these committees are limited in two important respects: 1) unless an individual is a member of the appropriate society, information generated by a specific committee is very difficult to obtain, if, indeed, one is even aware that it exists; and 2) although members of the committees might be concerned about the need for conserving specimens, most are unlikely to perform research in this area. The latter is not unexpected because the professional interests of the committee members are focused on the natural science discipline, not on the conservation of specimens.

Professional Museum Societies

Natural history collections are also supported by the museum community. Professional societies in the museum community can be subdivided into several categories. Those that are most relevant to this paper fall under the groupings of 1) general museum societies, 2) conservation societies, and 3) museum societies with a natural history orientation. Most of the societies within the first grouping emphasize the museum as the primary focus; collections are considered one of several subdivisions within this primary focus. This group includes museums of all disciplines. In contrast, the primary concern of the conservation societies is the long term preservation of material. Included within these two types of professional societies are at least 11 international and national societies, and numerous regional organizations (Table 2). As with the professional societies in the natural

Table 2. Geographic scope of professional museum and conservation societies.

- International
  - Museum focus
    - International Council of Museums (ICOM)
  - Conservation focus
    - International Institute for Conservation of Historic and Artistic Works (IIC)
    - ICOM Committee for Conservation
    - ICOM Committee for Conservation—Natural History Working Group
    - International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM)
- National
  - Museum focus
    - American Association of Museums (AAM)
    - American Association for State and Local History (AASLH)
    - Art Museum Association of America (AMAA)
    - Canadian Museums Association (CMA)
  - Conservation focus
    - American Institute for Conservation of Historic and Artistic Works (AIC)
    - Canadian Conservation Institute (CCI)
    - National Institute for the Conservation of Cultural Property (NIC)
- Regional
  - Museum focus
    - 6 regional associations in AAM
      - Mid-Atlantic Association of Museums, Midwest Museums Conference, Mountain–Plains Museums Association, New England Museum Association, Southeastern Museums Conference, Western Museums Conference
    - 9 provincial associations in CMA
    - 34 state associations in AAM
  - Conservation focus
    - Numerous

history disciplines, the museum and conservation societies vary greatly with respect to the purpose of the society, the geographic scope of their members, and the degree to which each focuses on collections.

Within both of these groupings, the national and international societies focus primarily on broad issues and issues of national and international significance. It is at these levels that research is most strongly encouraged. For example, the American Association of Museums (AAM) in cooperation with the National Institute for the Conservation of Cultural Property (NIC) and the American Institute for Conservation (AIC), conducted a study to examine the major aspects of collections care within the institutional context of museums (AAM, 1985). This study has provided a general framework to document collection needs based on all types of collections. However, in spite of the stress placed on the importance of research concerning the problems of specimen care, preservation and management, there is not a good mechanism to report the findings of individual researchers to the museum collections community.

The regional and state organizations focus more heavily on local issues and the daily operational needs of museums and conservators. Among the museum societies, there is a strong emphasis on "how-to-apply the theory" workshops and panels. These are valuable for the dissemination of information, but do not encourage research on particular problems.

General museum and conservation societies provide the structure for and encourage interchange between different types of museums and different disciplines. This interchange is critical for the discussion of philosophical and ethical issues as well as the sharing of information. Consider, for example, the computerization of specimen data in collections; due to the structured nature of data in natural science collections, much of the pioneering work in computerization took place in natural history collections. Computerization has since expanded rapidly into other fields. Another example can be found in the conservation of natural history collections. Although the specimens in these collections have many unique characteristics, the vast amount of knowledge used in the conservation of historical and artistic works provides a strong basis for work with natural history specimens.

Museum societies also provide a forum for discussion among different subdisciplines within museum science. It is through these societies that the educators, exhibitors, curators, and administrators have the opportunity to communicate and exchange ideas. It is important for each subdiscipline to understand the needs and goals of the others so that the common interfacing within the museum operational structure may be successful.

From the perspective of professionals managing natural history collections, however, museum and conservation societies have some limitations. Once again, the primary focus of these societies lies somewhere other than with natural history collections, and the specialized needs of these collections can be dealt with only in part by general museum and conservation societies.

The third category of professional societies in the museum community are those concerned with natural history museums and collections. These may be subdivided into two groups: those which deal with natural history museums as a total entity (Natural History Committee of ICOM, Natural History Affinity Group of the Mountain-Plains Museums Association and the Association of Science Museum Directors), and those which deal primarily with natural history collections (Biological Curators' Group, BCG; Geological Curators' Group, GCG; Association of Systematics Collections, ASC; and the Society for the Preservation of Natural History Collections, SPNHC). The societies in the first group are relatively small and informal organizations that are concerned with the philosophy and functioning of natural history museums. Because collections form the basis of such museums, however, they play an integral role in the goals of these societies. At present, these organizations contribute to the profession by sponsoring annual meetings and occasional newsletters.

Within the second group of natural history museum societies, two societies are concerned primarily with collections (SPNHC and ASC), and two have somewhat broader interests but remain strongly focused on the needs and concerns of specific types of collections (BCG and GCG). BCG and GCG are both based in the United Kingdom, and therefore reflect the needs and interests of professionals in that region. However, North American professionals need to be aware of these groups, their goals, and their activities so as to complement them rather than duplicate their efforts.

The BCG was founded approximately ten years ago as "a forum for discussion for museum biologists, (to provide) an opportunity to bring together and share expertise, experience and concern" (Davis, 1987). The three primary concerns centered on 1) biological recording—the collection, storage and dissemination of information about the natural environment, 2) biological collections and their current status, and 3) a liaison and monitoring role with regard to environmental issues (Davis, 1987). One of the primary purposes of the GCG is "to improve the standard of geological curation and to advance the education of the public in geology by improving displays and information in public museums and other institutions" (1986 proposed constitutional amendments). Both societies hold annual meetings, publish newsletters and support projects which serve to improve the situation of collections. One such project has resulted in the publication of "Guidelines for the Curation of Geological Materials" (Brunton *et al.,* 1985).

ASC was founded "to foster the care, management, preservation, and improvement of systematics collections and to facilitate their utilization though the following services:

—providing representative spokesmen for institutions housing systematics collections;
—encouraging direct interaction among those concerned with systematics collections and their use;
—providing a forum for consideration of mutual problems;
—and promoting the role of systematics collections in research, education and public service through coordination of information about the needs of users, planning and implementation of advisory services, and development and implementation of national goals and priorities" (Humphrey, 1972).

The society was initially oriented to represent professional systematics societies and institutions but was opened to individual memberships in 1982. The primary types of collections that are represented by ASC include tissue and culture collections, microbiology, worms, mollusks, insects, invertebrates, vertebrates and plants. It should be noted that anthropology, archaeology, geology and paleontology collections are not among those included.

ASC has been expanding its efforts to inform and work with federal agencies in the United States which are responsible for funding levels and legislation affecting systematics research and collections. It currently sponsors an annual meeting, a newsletter, and has been involved with several projects resulting in publications useful to various portions of the systematics collections community (Edwards *et al.,* 1981; Lee *et al.,* 1982; Dessauer and Hafner, 1984; Edwards *et al.,* 1985; Kim and Knutson, 1986; Zycherman and Schrock, 1988). However, because of its institutional and societal emphasis, there has been little encouragement or reporting of research performed by individuals concerning specimen preservation and management.

The SPNHC is a relatively new professional society that is also concerned with the development and preservation of natural history collections. The emphasis of the society is on research and projects completed by individuals that pertain to the preservation and management of natural history specimens. The natural history fields represented include anthropology, archaeology, botany, geology, paleontology, and zoology. This society now sponsors an annual meeting and publishes a journal, *Collection Forum,* and the *SPNHC Newsletter.* As it grows, this society has the potential to serve as the primary forum for the growth and

Table 3. Overview of professional societies.

Societal focus	General interest in collections	Interest in natural history collections
Natural history disciplines	limited	limited
General museum	high	limited
Conservation	high	limited, growing
Natural history museums/collections	high	high

dissemination of knowledge concerning the management and conservation of natural history collections.

In addition to the societies already mentioned, there are a variety of specialized societies outside the museum community (for example, the Biodeterioration Society and the PanAmerican Biodeterioration Society) as well as museum societies in other regions of the world (for example, the Museums Association in the United Kingdom, the Museums Association of Australia, and the South African Museums Association) which may deal with topics of interest to personnel in North American natural history collections. The problems, however, are two-fold: 1) access to the society and its information, and 2) specialization and/or regionalization. Both of these limit the degree to which these societies might serve the needs of natural history collections in North America.

Table 3 summarizes the degree to which the various museum and natural science professional societies serve the needs of natural history collections. It is only the natural history-oriented museum societies which address to any degree the needs of professionals managing natural history collections. However, most of these are growing and still in the process of defining their purposes and levels of activities. Most likely, it will require an interaction of all of these societies to foster the necessary support for personnel dealing with natural history collections.

Literature

A body of literature is of concern for any discipline; it is critical for the dissemination of knowledge and for the growth of new knowledge. Such a body of literature must encompass at least four levels of thought and knowledge: philosophy of the discipline, foundation research (surveys and descriptive studies to establish a basis for the field), theories pertaining to various aspects within the discipline, and research dealing with these aspects.

Needless to say, it is not strictly a matter of the quantity of literature; the quality and availability of materials are critical. Quality within a profession, whether dealing with publications, grants or any type of accreditation process, is most commonly controlled and upgraded through some sort of peer review (Griesemer, 1985; Swank, 1985; Brush, 1986). It is a process which requires time and effort by many people, but it is the only proven method for improving quality within a professional society.

Availability is a major problem not only for literature dealing with natural history collections, but for all museum science literature. As an example, only one publication out of a dozen cited in several recent articles dealing with collection problems is available at the Texas A&M University library, a library which contains some 1.4 million volumes and services 38,000 students and over 2,200 faculty members. Texas A&M does not have a museum, but it does have 27 natural science collections on campus, among which are four that rank within the top ten university collections in the US. A lack of ready access to pertinent literature is, unfortunately, more the rule than the exception.

The problem of availability is even worse in countries outside of North America, particularly in the developing countries. A survey by Mares and Braun (1986) concerning the existence and availability of popular and technical literature of mammalogy outside of North America also questioned the respondents about museum science literature pertaining to mammalian collections and natural history museums. Responses came from 104 individuals in 55 countries, but only 30 countries reported access to literature discussing collection and preparation of specimens; 14 had access to general museum science literature, but no one reported access to literature discussing the importance and operations of natural history museums. Even if some literature were available to an individual, it was generally limited to no more than three publications.

Two articles summarize much of the literature that might be available and pertinent to natural history collections in North America. Stansfield (1985) is concerned specifically with literature relating to natural history museums. After pointing out that a comprehensive work dealing with current philosophy and practices of natural history museums does not exist, he subdivides the current resources into four categories: periodicals and indexes, bibliographies, proceedings, and irregular publications, theses and monographs. Stansfield subdivides the periodicals and indexes into three groups: 1) four are substantial regular publications (*Curator, Museum, Museums Journal, Museum News*), but only one of these (*Curator*) deals with natural history on any regular basis; 2) five are general publications which occasionally deal with natural history, but are not as easily available (*Muse, Muse News, South African Museums Association Bulletin, Studies in Museology* from India, *Journal of Indian Museums*); and 3) six are less substantial publications which deal with natural history museum concerns, but may be irregular in publication and/or limited in circulation (*ASC Newsletter, BCG Newsletter, The Geological Curator, ICOM Natural History Newsletter, Der Präparator, Bulletin de Liaison des Musées d'Histoire Naturelle*). This list is incomplete, and in this lack of completeness, points out the problem of access to the literature which does exist.

The four bibliographies listed by Stansfield (1985) are of limited value due to the general nature of each, and the limited availability of at least one (*ICOM International Museological Bibliography, Selected Bibliography of Museological Literature* published in Czechoslovakia, *Art and Archaeology Technical Abstracts, Zoological Record*). Three additional bibliographies which might be of value to natural history collections but were not included by Stansfield are Hicks and Hicks (1978), Williams *et al.* (1979a), and Shchepanek (1983).

Stansfield also lists approximately a dozen proceedings and irregular publications dealing with natural history collections and/or museums. These publications are often among the most valuable for the professional, because they tend to include detailed recent information about specific topics. However, they are frequently the most difficult to obtain. The first problem is becoming aware that they even exist; the second is actually obtaining a copy.

Griesemer (1985) approaches the question of literature from the broader per-

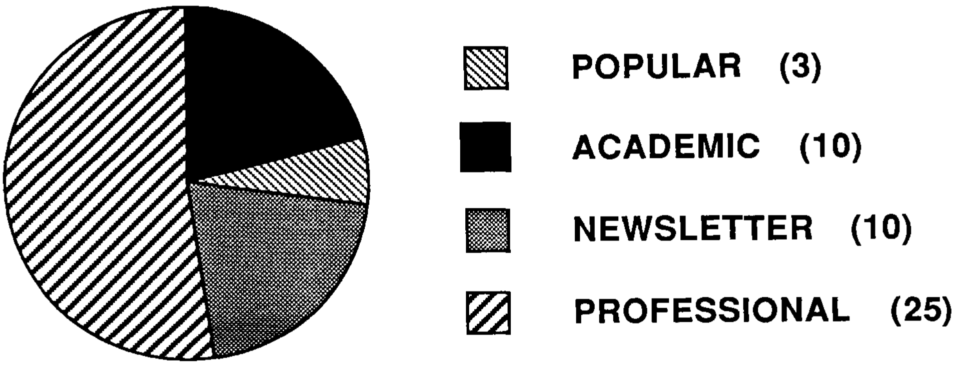

Figure 1. Forty-eight of the 125 publications located by Griesemer (1983) serve museology.

spective of museum science in general. His list of 125 publications is the result of a questionnaire designed not only to locate the publications but to categorize them according to type of publication (academic, professional, popular, newsletter), the discipline(s) served (art, education, history, science, museology), whether or not the publication accepts unsolicited manuscripts, and the type of review process, if any.

Forty-eight of the 125 publications serve museology. Twenty-five of these are professional journals, ten are academic, ten are newsletters, and three are popular (Fig. 1). This somewhat impressive total becomes less so when one questions whether these 48 journals serve the needs of professionals managing natural history collections. Newsletters and popular publications are general in content and frequently regional in approach; thus, they are not appropriate sources for articles on the preservation and conservation of natural history collections. Of the ten academic publications, six deal with archives and library interests, three are history-oriented, and only one includes natural history (*Curator*).

Within the category of professional journals, the list is again quickly diminished (Fig. 2). Only six of the 25 publications might be possible sources for articles dealing with natural history collections. Of these possibilities, one is oriented entirely towards the philosophy of museum science (*MuWop*), three deal with museum issues on a general level (*International Journal of Museum Management and Curatorship, Kalori,* and *Muse*), and two serve a general museum audience but do address more specific issues (*Museums Journal, Museum Studies Journal*). The latter deal with natural history occasionally. Therefore, only one of the 125 publications listed by Griesemer (1985) serves the interests of natural history collections with any regularity. Griesemer's list is not, of course complete as it relied on responses to a questionnaire. However, it does point out a void in the museum science literature with respect to natural history collections.

An additional step in this review of literature pertaining to natural history collections was a content analysis of 16 journals in the disciplines of museology and natural history. A journal reflects the goals of the society which publishes it, and, therefore, is a direct indication of the emphasis each society places on natural history collections. The journals selected had to meet the following criteria: production by a professional society or organization, regular publication, wide circulation and availability, and recognition as a substantial publication. Eight pub-

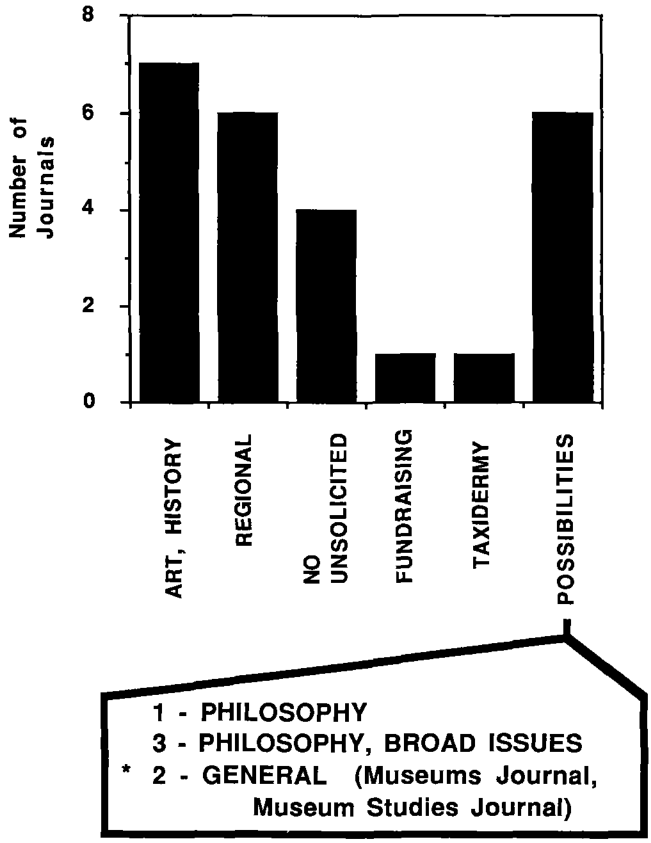

Figure 2. Only two (*) of the 25 professional museum journals located by Griesemer (1983) might contain articles pertaining to natural history collections.

lications dealing with vertebrates and two with botany were selected as examples of journals produced by professional societies with natural history orientations. It should be noted that an additional bias exists in the selection of these ten publications; these ten were selected because they were the *most likely* to contain articles pertaining to collections. *Curator* and *Museum Studies Journal* were included for this reason as well even though they are not produced by professional societies. (Note: *Collection Forum* was not included in this analysis, because it was barely one year old at the time of the analysis.)

Table 4 summarizes the results of content analysis for journals published in 1985 and 1986. None of the vertebrate-oriented journals published more than one collection-oriented article over the two year span. None of the articles were feature articles, and the longest was a listing of acronyms for collections (Leviton *et al.*, 1985). The majority of the articles in the botanical journals dealt with preparation techniques for certain species.

As one might predict, the greatest number of articles relating to natural history collections appear in *Curator.* It is also interesting to note that *Museums Journal* and *Museum Studies Journal* follow with the most collection-related articles. The results of these content analyses support the conclusions that the primary interests

Table 4. Summary of articles with natural history collection orientation published in journals during 1985 and 1986.

Journal	Pages in journal	Pages Re: collections No.	Pages Re: collections %	No. of articles Re: collections
Natural history disciplines				
Auk	1,611	13	0.8	1
Wilson Bulletin	1,097	1	0.1	1
Condor	1,069	2	0.2	1
J. Mammalogy	1,536	7	0.5	1
J. Herpetology	1,118	0	0	0
Copeia	2,041	30	1.5	1
Systematic Zoology	1,072	4	0.4	1
Canadian J. Zoology	2,869*	0	0	0
Taxon	1,393	38	2.7	14
Annals Missouri Botanical Garden	1,704	24	1.4	4
Total	15,510	119	0.8	24
Museum publications				
Curator	598	204	34.0	15
Muse	475	3	0.6	1
Museum	484	11	2.3	2**
Museum News	960	5	0.5	1
Museums Journal	406	10	2.5	4
		25	6.2	6**
Museum Studies	243	23	9.5	2
		21	8.6	3**
Total	3,166	302	9.5	34

* 1986 only.
** General collection orientation.

of the existing professional societies which publish substantial journals are not with natural history collections, and that only one substantial journal regularly serves the needs of natural history collections.

Literature dealing with natural history collections is also available through a variety of irregular publications. Those listed in Table 5 are among the more useful recent publications which report on the care and maintenance of natural history collections. Each was published as part of an irregular publication series. The total number of pages and the number of articles contained in these publications support the claim that the number of articles published in the journals appearing in Table 4 is not indicative of the amount of material available for publication. However, the value of articles appearing in the publications of Table 5 is diminished because of the limited circulation and the problem of irregular publication.

Conclusion

A professional structure does exist to serve the needs of professionals responsible for the care and conservation of natural history collections, but it is relatively weak and unfocused. The structure can be strengthened only through the growth of societies and journals whose primary interests are in natural history museums and their collections. Since the analysis was completed, two new journals per-

Table 5. Recent publications on the care and maintenance of natural history collections appearing in irregular periodicals.

Date	Periodical, issue	No. pages	No. articles
1983	Syllogeus, No. 44 Natl. Museum of Natural Sciences, Canada	196	30
1984	Museology, No. 6 The Museum, Texas Tech University	32	1
1985	Occ. Papers, No. 25 British Columbia Prov. Museum	219	16
1985	Acta Zool. Fennica, No. 170	56	20
1985	Misc. Papers, No. 17 Geological Society	200	1
1986	Life Sciences Misc. Pub. Royal Ontario Museum	121	33
1986	Museology, No. 7 The Museum, Texas Tech University	78	1
1987	Herpetological Circular, No. 16, Soc. Study of Amphibians and Reptiles	70	1

taining to collections have been introduced: *Journal of Biological Curation,* published by the Biological Curators' Group, and *Journal of the History of Collections,* offered by Oxford University Press.

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ENDANGERED AND ORPHANED NATURAL HISTORY AND ANTHROPOLOGY COLLECTIONS IN THE UNITED STATES AND CANADA

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Abstract.—During 1987, a survey contacted over 700 natural history and anthropology collections in all states and provinces. Responses from 333 represent a range of collections from single discipline (e.g., malacology) to full museum (e.g., several departments with millions of specimens) and from a broad diversity of public and private institutions. Within this group, 30 percent acknowledged awareness of currently and potentially endangered collections, and well over half have taken into their collections materials which were endangered or orphaned elsewhere. The total cost of these transactions cannot be quantified. However, it can be analyzed on a purely financial and physical basis, in terms of resources lost or damaged, and in terms of either impairment or enhancement of the broad research and education endeavor in natural history.

For several years, both the Assocation of Systematics Collections (ASC) and the Association of Science Museum Directors (ASMD) have been vitally interested in the matter of important natural history and anthropology collections falling into disuse and either hopelessly deteriorating or moving physically into the possession of another organization. The dimensions of the matter have been largely unknown, however, and many reports were anecdotal. This absence of consistent data precluded consistent approaches to defining and dealing with the issue.

In 1985, the two organizations coordinated to conduct a preliminary study. Within ASC, this activity was a part of the function of the Council on Collections; within ASMD, it was as an Ad Hoc Committee on Endangered and Orphaned Collections.

The study was done via a survey sent to museum directors in the summer and fall of 1987. The sample of collections surveyed was drawn from the American Association of Museums and Canadian Museums Association directories, supplemented with names sent to me since 1985 as a result of an early ASMD survey and notes placed in the *ASC Newsletter, AVISO* and the *Chronicle of Higher Education.*

A working definition for "endangered/orphaned" collection was developed. This helped responding institutions and collections to work from a common understanding.

> "An endangered/orphaned collection is a substantive body of systematic material which is or soon may be no longer regarded as of value in its present ownership. This may be due to reduction of or absence of staffing or other support or negative or uninformed institutional policy decisions. The collection thus is in danger of becoming lost to the systematic research and education community. For the purposes of this study, the disciplines considered are limited to the areas of natural science (biology, geology and paleontology) and anthropology. Adoption or acquisition of an endangered/orphaned collection is an activity independent of the normal collecting activities of the museum, university or other entity."

Collection Forum, 4(2), 1988, pp. 65–74

Table 1. Survey respondents.

Category	Number
General	42
Natural history	82
Anthropology	48
Geology	26
Paleontology	14
Vertebrate paleontology	5
Invertebrate paleontology	3
Paleobotany	3
Micropaleontology	1
Zoology	18
Invertebrate zoology	2
Entomology	12
Malacology	2
Parasitology	1
Vertebrate zoology	3
Mammalogy	8
Ornithology	6
Herpetology	3
Ichthyology	6
Botany	32
Mycology	2
Diatoms	1
Living	9
Frozen tissues	1
Education	1

Respondents

Over 700 questionnaires were sent out; 333 were returned at least partially completed by December 7, 1987, and 10 were returned indicating the institution held no collections. Some institutions had each department or collection respond; many covered multiple collections in one response and some questionnaires were passed on to other organizations. While the breadth of coverage and the nature of the respondents are widely variable, reducing the sharpness of the data, the large number of responses probably gives a good overview of the broad systematics community.

Table 1 lists the respondents, arranged by collection type and discipline. General museums include broadly based organizations covering history, art and technology in addition to the traditional natural history disciplines. It also includes science-technology centers, children's museums, and others which have modest collections ancillary to their primary mission. Natural history museums encompass botany, zoology, paleontology, mineralogy and anthropology. A number of these replied as individual collections, so are included under the appropriate discipline. Anthropology collections are archaeology, ethnography and physical anthropology combined. Geology collections include paleontology, mineralogy and physical geology. All mineralogy is included in Geology. Zoology collections are broadly based, both vertebrate and invertebrate. All herbaria are included under Botany. Living collections include zoos, botanical gardens and cultures. Some botanical gardens reported only on their herbaria, so are included in Botany. The single Education collection is eclectic.

The overwhelming majority of collections covered by this study are in state/provincial, local and private not-for-profit organizations; these include both public and private colleges and universities, independent museums, research institutes, state parks and state/provincial and local museums. Eleven federally supported agencies are included: National Park Service units, some Federal research laboratories, the Smithsonian Institution and the Canadian national collections. Three personal collections replied, as did one corporate collection.

It is clear that this survey approach is not the ideal way to reach private, isolated collections. They frequently are not included in conventional listings and often feel threatened by inquiries on a national or regional scale. If it is desirable to bring private collectors into closer communication with institutional and thus more knowledgeable and stable collections, more effective contact will have to be made through hobby, fanciers' and specialists' groups. Many museum curators already are doing this, and some professional societies are diligently seeking and embracing private collectors as part of their mission. The recent American Society of Mammalogists report (Yates *et al.*, 1987) is an excellent example of this activity. Review of the number of very small mammal collections reported by Yates *et al.* substantiates that a disciplinary approach must be combined with the present "collections community" approach in order to gain a thorough understanding of systematics collections in the United States and Canada.

Acquisition Policies

Because the adoption of an orphaned/endangered collection involves the formal acquisition of materials, respondents were asked if they have a written policy for the acquisition of collections from outside organizations or individuals. Of the 322 responses to this question, 131 (41%) indicated that they do have such a policy, and another 41 (12%) had one in preparation or being revised. One hundred and fifty-one respondents (47%) indicated that they did not; a number of these, however, said that acquisition of endangered collections takes place under circumstances identical to those of conventional collecting activity. Thus, the number of negative responses is high.

Sixty respondents attached policy statements to their completed questionnaires. There is great variation among these. Most have a scope of collections statement which can provide guidance to staff in determining whether a particular object or collection should be accepted. Others, however, deal primarily with accession and catalogue procedures and do not provide policy direction.

The other important policy deals with deaccessions. Because of the legal exposure collection managers and institutions have when items formally leave their care, these policies and procedures tend to be well thought out. Most involve several levels of review, requiring that the curator process a deaccession through higher authority before dispersal can be effected. Multiple approaches to this will be discussed later in this report.

These acquisition and deaccession policy statements are now on file in the offices of the Association of Systematics Collections, 730 11th Street, N.W., Washington, D.C. 20001.

Knowledge of Endangered Collections

Only 36 (11%) of the respondents indicated that they maintain a formal listing of currently or potentially endangered collections. On the other hand, 92 (30%) do know of currently or potentially endangered collections. Ten of those 92 explicitly declined to mention any such endangered collections because of ongoing negotiations. Other respondents, including those within the 214 (70%) who do not now know of endangered collections, also mentioned the need for confidentiality. Presumably this is a concern in terms of interinstitutional competition; potential recipients do not want competing offers from other institutions both to avoid losing a collection which is geographically, topically or politically important and to avoid competitive price increases.

Thirty-seven of those who know of endangered collections mentioned specific instances. Four regarded their own collections as potentially endangered. The other 33 referred to 55 specific collections in the disciplines of concern here.

Three professional groups were mentioned as serving as clearinghouses for endangered collections: the Mineral Museums Advisory Council, the American Ornithological Union's Committee on Collections, and the American Society of Mammalogists' Systematic Collections Committee.

Receipt and Costs of Endangered Collections

Well over half (196) the respondents have taken into their ongoing collections materials which were endangered or orphaned. The intensity of participation in this activity is variable. For some collections, it was accepting a few dozen specimens from a private collector; for others, it was incorporation of major collections from other institutions. A number of such transactions in mammalogy are indicated in Yates *et al.* (1987:59–63, Table 2).

Based upon this sample of North American natural history collections, it seems that the majority are to some extent participating in the process of collection movement. Thus the cost in real dollars, as well as in curatorial time and space, is spread across a broad spectrum of institutions. It should be noted simultaneously, though, that many of these collection shifts were carefully negotiated and sought by the recipient. To categorize all acceptance of endangered collections as simply altruistic is a significant overstatement.

Central to the endangered collection issue is the actual dollar cost of incorporating materials into an existing collection. Some institutions, to a great extent because of the need for providing data in support of National Science Foundation collection improvement proposals, have detailed information. Others either do not acquire such collections because of the cost, or regard such acquisition as normal activity and therefore cost is not calculated. Almost all recipient collections do not pay much attention to adding small quantities of specimens; it is the large acquisitions which cause financial distress.

Table 2 lists examples of costs. There are wide disparities depending upon the discipline involved and the means of calculation. Archaeological collections are often funded externally, permitting the much higher figures.

Table 3 is based on material distributed at the 1985 American Association of Museums Annual Meeting detailing costs incurred by the California Academy of Sciences in adopting a number of biological collections.

Table 2. Estimated costs of adoption, by category.

Natural history: $0.25–$0.75 per specimen or catalogue entry
Anthropology: $1.00–$200 per artifact; $100–$1,000 per cubic foot
Paleontology: "several"—$20 per specimen or lot
Vertebrate paleontology: $7.00 per specimen
Invertebrate paleontology: $5.00–$6.00 per lot
Zoology: $0.33–$10.00 per specimen
Entomology: $0.25–$4.00 per specimen; $5.00 per lot
Malacology: $3.50–$5.00 per lot
Parasitology: $0.75–$1.00 per slide or vial
Mammalogy: $5.00–$16.00 per specimen
Ornithology: $10.00–$12.50 per specimen
Herpetology: $3.40 per specimen
Ichthyology: $3.00–$10.00 per lot
Botany: $1.00–$1.60 per mounted specimen; $3.00–$3.50 per unmounted specimen
Mycology: $2.00 per specimen

Table 4 indicates the nature of data, support and restrictions which accompany collections. It clearly is expected by the donor, whether institutional or individual, that the recipient has on hand, or access to, resources necessary to handle this responsibility.

Future Capabilities

When asked about their future ability to adopt collections, the majority of respondents cited space limitations. The second concern is limited staff; a number of university-related collections share their staff with teaching departments, and some are managed by full-time academics only as time is available.

On the other hand, a small percentage describe themselves as either new institutions or having facilities that are significantly improving. Therefore, they easily are able to accommodate significant collections in the foreseeable future.

A number of collections link accepting outside collections directly to the availability of outside support, either from the National Science Foundation or other sources. Likewise, a number of respondents indicate that they will take in materials only for exhibit and education purposes, leaving research collections to larger, better-staffed, and (by implication) better-funded organizations. A very small number suggested that existing administrative policies discourage adding to collections at all.

Dispersal

The possible dispersal of institutions' own collections is dealt with in three general ways: 1) placement in another institution, sometimes with sale as an ultimate action; 2) absence of a written policy; or 3) a non-issue as there is neither expectation nor evidence that it might occur and/or existing policies do not permit dispersal.

Within the first category, there is a general pattern of initially seeking to exchange collections or parts of collections with comparable institutions. If the dispersal were to occur because of research inadequacy of the collection materials, attempts usually are made to maximize educational benefits through the museum itself or

Table 3. Endangered biological collections adopted by the California Academy of Sciences.

Source	Date received	Size	Approximate costs (for housing, curation, incorporation, and transport, including costs for personnel, equipment, and supplies) CAS	NSF	Other
		Department of Botany[1]			
Praeger Herbarium	1955	70,000	$ 60,000	$ —	$ —
Merriam Herbarium	1970	4,000	4,800		
Twisselmann Herbarium	1973	20,000	5,500		
Stanford (Dudley) Herbarium	1976	800,000	1,000,000	992,772/8 years	70,000
U.S. Forest Service Herbarium	1980	4,000	800	20,000	
J. R. Shevock Herbarium	1983	10,000	250	2,500	
Subtotals		908,000	1,071,350	1,015,272	70,000
		Department of Entomology[2]			
Pomona College	1980	75,000	$ 22,000	$ 15,000	
University of California, Berkeley	1981	150,000	55,000	13,000	
Blivon Collection	1983	45,000	32,000	2,000	
Wilcox Collection	1984	80,000	25,000		
Subtotals		350,000	134,000	30,000	
		Department of Herpetology			
Stanford University	1968	65,000	$ 12,900	$ 143,800	
		Department of Ichthyology[3]			
Indiana University	1928	20,000	$ 5,000		
Vanderbilt Foundation	1967	45,000 lots		$ 177,600	
Stanford University	1969	70,000 lots		89,000	
Subtotals		135,000	5,000	266,600	
		Department of Ornithology and Mammalogy[4]			
Loukaskin Collection (Harbin University)	1949	1,600	$ 15,000		
Stanford University (bird skins)	1964	13,000	35,000	$ 45,000	
Stanford University (mammal skulls & skins)	1964	3,000			volunteer help

Table 3. Continued.

Source	Date received	Size	Approximate costs (for housing, curation, incorporation, and transport, including costs for personnel, equipment, and supplies)		
			CAS	NSF	Other
K. Walker Collection (skulls & skins)	1982	110	3,500		$ 1,500
W. Brown Collection (skins)	1977	504	8,000		
Subtotals		18,214	61,500	45,000	1,500
	Departments of Invertebrate Zoology and Geology[5]				
Stanford University (fossils)	1977	25,000	$ 59,000	$ 48,000	
Stanford University (recent)	1977	45,000	30,000	60,000	
Hopkins Marine Laboratory	1977	4,000	10,500	5,000	
University of California, Berkeley	1978	1,000	2,200		
Pacific Marine Station	1979	4,000	4,500		
Subtotals		79,000	205,700	113,000	
Totals	24 major collections	1,502,564 specimens	$1,390,950	$1,613,672	$71,500
Average cost per specimen, ca. $2.00					

[1] Costs for transfer of Stanford collection do not include CAS staff time to catalogue and/or incorporate 2,000 books and 100,000 reprints.

[2] This list is simply a sample of major collections received during the past four years in Entomology. Perhaps over 2,000,000 specimens have been received in this manner in the past six decades, few from institutions, mainly from private individuals. Unlike most other disciplines, many professional and amateur entomologists develop and maintain large insect collections. These often end up in institutions such as ours when the individual dies. Such transfers are sometimes, but not always, by prior arrangement (will), but the timing of transfer (upon death) is seldom predictable in advance. Hence, the impact on the museum's resources in any given year is unpredictable. These personal collections are often even more important in some respects than institutional collections; and it frequently becomes a museum's responsibility to permanently care for such collections, often on short notice.

[3] There are numerous other, smaller collections which have been received from other institutions or organizations, but costs for each could not be itemized.

[4] Although private collections of mammals and birds are few, some do come to our museum for deposit. The Ray Bandor Collection of mammal skulls and skeletons is one such collection which will eventually come to the Academy. The costs for transferring, housing, curating, and maintaining such a collection are difficult to estimate but may run well over $100,000.

[5] As with Entomology, IZ&G receives private collections from time to time, under similar circumstances.

Table 4. Items accompanying collections (number of responses).

	Always	Usually	Seldom	Never
Adequate data	18	154	106	5
Required—8				
Support				
Cases, etc.	5	31	138	101
Conservation	2	4	106	156
Salaries	3	—	39	232
Space	—	2	49	217
General endowment	—	2	43	213
Restricted endowment	—	2	71	192
Use restriction	4	19	130	115
Not allowed—14				

other educational organizations. If exchange is not possible, gift or sale to another museum is the next usual possibility followed by public sale. The ultimate means of dispersal, particularly of very low quality materials, is witnessed destruction. There is a strong desire to maintain collections in the public trust and to sell to the for-profit sector only after extreme efforts have been made to find an institutional home. Some collections would attempt to return specimens to the donor, although there is recognition that there are tax-related questions involved in this action.

In the second instance, when there is no written policy, many institutions follow the general pattern outlined above. A number, however, leave the matter up to the curator or determine their course of action on a case-by-case basis. Many government-owned collections must go to another agency of the same government if they leave their present ownership, so the policy has been externally determined.

The majority of respondents, even if they have formal statements directing how a dispersal should occur, either have not had to dispose of parts of their collections or have done so as a conscious curatorial/collection management strategy. Even if they are not in the position to acquire additional material, very few have had to make the difficult decision to unwillingly disperse parts of their own collections.

General Observations

Observations about the state of systematics collections produced several broad conclusions. There is a general consensus that de facto centralization is occurring. While many see centralization as necessary for the survival of many collections, there also are laments that it is significantly damaging education in systematics. In paleontology, increasing use of replicas somewhat ameliorates this. Similarly, botanists regularly collect multiple specimens from a single plant and deposit these in numerous herbaria.

Legislation governing collecting, both broadly and of particular species or antiquity, is limiting the development of new private collections. The number of private collections now coming into institutional possession, thus, will probably decrease in the future. On the other hand, contract salvage work (largely archaeological) is producing objects at a very high rate.

There is a broad feeling that college and university collections, particularly the smaller ones, are generally in more vulnerable condition than is desirable. This contributes to difficulties not only with curation, but also with general conservation. The level of museological training and awareness is believed to be lower in the smaller and less systematic institutions (e.g., science-technology centers, children's museums, general museums).

Several anthropological collections called attention to the threat of repatriation, particularly of Native American materials but also of cultural items from various parts of the world. Occasionally this is dealt with as a policy issue; some growing collections refuse to deal with Native American archaeology.

Many respondents are encouraged by the rapid improvement of collection management procedures. Of particular value is the increased use of computers as a collection management tool. The counterbalance to this is the apparent decrease in number of curators in some disciplines, leading to broad disparities in the curation of collections within that discipline. Invertebrate Zoology and Malacology were the most frequently mentioned in this regard.

Many mentions were made of developing networking systems which allow data exchanges and encourage selective rather than foraging use of collections. The National Park System network was mentioned as well as the Canadian Heritage Inventory Network. ASC is looked to by some as playing a networking role, as are the disciplinary societies. Some museums are aware that they are outside the existing informal networks and look to more inclusive organizations to assume the function of bringing collections together.

Respondents analyzed reasons for endangered/orphaned collections in several ways. It was pointed out that many "orphanings" are intentional; the collector expected to pass the collection on to an institution and the institution knew this in time to make the necessary preparations. Much attention was called to institutional personnel and policy changes which endanger all or part of collections. Universities are seen as much more susceptible to this than museums, particularly because of the space necessary for systematics collections and the apparent movement of Federal research support into non-systematic fields. Many noted that the specialty of faculty positions has tended to move away from systematics as a result of retirements and job changes. Also, it was noted that frequently these changes will result in the orphaning of a segment of a collection; thus, while the collection formally remains intact, significant parts of it are ignored or dispersed.

There is a minority feeling that research collections are incompatible with a significant public exhibit commitment on the part of museums. These respondents believe that the concentration of collections in research institutes will both ensure the future stability of the collections and provide more professional care for them.

Conclusions

There are tensions among institutions about collections. There are differences on the centralization-decentralization matter. There are concerns about the movement of regionally important collections to other parts of North America or even outside the continent. There are concerns about "outside" institutions collecting in one's immediate vicinity. There are concerns about how and where to carry on the education of the next generation of systematists. There are worries that large organizations are intending to "raid" smaller ones for collections. There are concerns that collections will be increasingly less available for both research and education.

This general survey has demonstrated that there are serious issues within the systematics community about the well-being of its basic resource. The dynamics of collection growth, development, change and movement are complex and probably impossible to quantify. Nonetheless, the evidence strongly suggests the need for: 1) careful communication and cooperation among the organizations responsible for systematics collections; 2) broad infusions of external funds to not only improve existing collections but also ensure the physical survival of important endangered collections; and 3) joining of the disciplinary societies with museological and educational advocates to maintain a clear and broad view of our systematics collection resources.

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BOOK REVIEWS

THE ORGANIC CHEMISTRY OF MUSEUM OBJECTS, 1987. John S. Mills and Raymond White (Butterworths, London, 165 pp.). This book aims "to provide an account of the composition, chemistry and analysis of the organic materials which enter into the structures of objects in museum collections." This covers an astoundingly broad range of materials, especially remarkable in such a slim volume (165 pages). The book begins with two introductory chapters on basic organic chemistry and analytical methods. They are followed by eight chapters, each devoted to specific materials: oils and fats, natural waxes, bituminous materials, carbohydrates, proteins, natural resins and lacquers, synthetic materials and dyestuffs. The last two chapters cover the fundamental aspects of deterioration and analysis in practice.

By far the most informative and useful sections of the book are chapters three through ten, dealing with the specific materials. Each chapter provides a good, basic description of the structure of the materials covered and the chemical reactions that they undergo. For museum professionals, the discussions on the properties, stability and deterioration of these materials is of particular interest. Given the authors' positions at an art museum, it is understandable that the text consistently draws on examples from fine arts collections. Because they are dealing with the raw materials of these objects, however, most of the information presented is applicable to natural history collections. After all, cellulose is cellulose whether it is a piece of paper that Leonardo da Vinci drew on, part of a New Guinea dance mask or a dried botanical specimen.

Chapters two and twelve which focus on analytical methods are also of great interest. The former clearly explains the analytical techniques used to isolate and identify the materials covered in this book. Chapter twelve augments this basic information by presenting actual case studies that illustrate how these analytical techniques work, what they can determine and what their limitations are.

The weakest parts of the book are chapter one, basic organic chemistry, and chapter eleven, the fundamental aspects of deterioration. Both chapters attempt to cover too much complex material in too little space. In the former, explanations are so cursory as to lead to confusion and bewilderment in any reader without a working knowledge of organic chemistry. The reader without such knowledge would be much better advised to go to an organic chemistry textbook for this background. Chapter eleven, as well, attempts to cover the extremely complicated subject of the deterioration of organic materials in a very few pages. Because deterioration is covered to a certain extent in the relevant chapters on specific materials, it probably would have been better to leave this chapter out.

In spite of these weaknesses, this book definitely fills a need by providing a useful compendium of information for the museum professional, especially the conservator. While most of the information presented in this book is available elsewhere, it is very scattered throughout the literature. The importance of this book is that it brings all the information useful to museum professionals together in a single volume. Also worthy of note is the extensive bibliography at the end of each chapter that can steer the reader on to more detailed information if desired. Although not the stated aim of the authors, this volume will certainly become a useful reference book about organic materials for museum professionals.—*C.*

Sease, Conservation, Field Museum of Natural History, Chicago, Illinois 60605-2496.

HERPETOLOGICAL COLLECTING AND COLLECTIONS MANAGEMENT, 1987, John E. Simmons (Society for the Study of Amphibians and Reptiles, Herpetological Circular 16:70 pp.). The collecting and preservation of amphibians and reptiles as scientific specimens, and the maintenance of those specimens in collections for study, have traditionally been highly idiosyncratic activities. The techniques and methods used by a particular curator or collector have always reflected more the history and training of the individual than any conscious attempt to achieve optimum results. Institutions, equally, have been saddled with historical artifacts of methodology—the "we have always done it that way" syndrome. But no more. John Simmons has provided, in a tightly packed 70 pages, everything that anyone could ever want to know about herpetological collecting and collections. Moreover this is more than a manual of suggested techniques—it is a remarkably complete, concise, and unassailably correct reference to "how it should be done."

The circular consists of three basic sections: field collecting (including collecting, preservation, and documentation of specimens), the museum collection (with step-by-step outlines for each procedure from accession to housing of specimens), and museum collection management (loans, collection growth, etc.). Each topic is extensively referenced, and the 14 page bibliography (in very small type) is probably the most useful part of the circular. But the best feature of the publication is Simmons' style. Each topic is introduced with a logical approach, and the recommendations are neither preachy nor dogmatic. Simmons avoids getting bogged down in minor controverseries such as the best format for specimen cross-reference files, or what is the "right" type of jar. Where there is a genuine difference of opinion both sides of the case are fairly put, with advantages and disadvantages clearly spelled out. Some of the most persistent bad habits of herpetological collectors and curators (made-up field numbers, tape recorded field notes, for example) are solidly discouraged. The collection organization and management procedures described are, if anything, utopian. But I admit that a collection organized and run strictly according to Simmons' recommendations would be a model of its kind.

Finally, in addition to the "nuts and bolts" of collection management there are admirable philosophical discussions on such pertinent issues as the future of systematic collections, the responsibilities and duties of collection staff, and ethical and legal considerations in collection acquisitions. The last should be required reading (perhaps even regularly required) for all curators.

This circular should be in the hands of everyone who has any level of responsibility in an herpetological collection. It is an indispensible reference, and a remarkable bargain at the price ($6.00; copies available from R. D. Aldridge, Biology Dept., St. Louis University, St. Louis, MO 63103).—*C. J. McCoy, Section of Amphibians and Reptiles, The Carnegie Museum of Natural History, Pittsburgh, Pennsylvania 15213.*

A GUIDE TO MUSEUM COMPUTING, 1987. David W. Williams (Am. Assoc. State and Local History Press, Nashville, 181 pp.). Don't be put off by the 3-D graphics design on the cover. This book really is a detailed primer for the beginner in museum collection computerization. When you don't know enough about the subject to ask the right questions, this book introduces the questions and sends its readers on the path to finding the right answers for themselves. David Williams provides a step-by-step, logical approach to the decisions required when computerizing a museum collection.

The book contains 120 pages of text followed by a four-page glossary, a brief bibliography, and seven appendices. The Introduction gives an historical prospective which also serves to introduce and explain some of the appendices. The overall content of the Introduction is rather uneven. Williams tries very hard to reassure novices but dwells too long on some of the difficulties of past computer projects. A person who has been through the computerization process can nod in agreement about the points he makes, but technology has changed greatly since the days of SELGEM. Although the author mentions that technological changes bode well for small collections, he describes systems and quotes prices in the $18,000 to $100,000 range. This information is hardly encouraging for small collections.

Chapter 1, "Computers in the Museum," briefly discusses the rationale for computerizing a museum collection and continues to reassure the uninitiated. Pointers are given on how much one needs to know before making an intelligent purchase of hardware and software. Williams also offers suggestions about how and where to acquire the essential knowledge.

Chapter 2, "Designing a Computerized System," is full of good suggestions. Unfortunately for natural history professionals, David Williams' background is in art and general history museums. As a result, his examples throughout the main text are specific to those types of collections. As museum people are constantly being forced by the rest of the world to substitute collection categories for business-oriented fields, Williams' treatment is a welcome improvement.

Chapters 3 and 4, "Choosing the Right Software" and "Choosing the Right Hardware," provide many, many useful ideas for the novice. These two chapters alone are probably worth the price of the book. The author explains computer jargon that one needs to know as he leads the reader through all the important considerations to be made before purchasing software, then hardware. His ideas are logically presented and fully detailed.

Chapter 5, "Implementing Your New System," steps through the duties of making the system your own. From methods of capturing old records, to correcting errors, and the all-important task of writing a manual for your system, Williams makes suggestions about various approaches. Once again, one is forced to superimpose natural history collections over art museum examples.

The appendices include several examples of systems operating at museums which had been described in the Introduction. Lack of specific natural history collection examples elsewhere is covered here by a presentation of the system used for the anthropology collection at the Utah State Museum of Natural History. One appendix also provides sample worksheets used by several collections.

David Williams' writing is easy to read because he succeeds in keeping it simple. So much that is written about computers is full of jargon that reading can be painfully difficult. The mental gymnastics involved in converting from business applications to museum settings also adds to the frustrations of trying to read articles on a usually bone-dry topic. It is obvious that David Williams has considerable experience with the subject, yet he has no trouble talking to the beginner.—*S. B. McLaren, The Carnegie Museum of Natural History, 5800 Baum Blvd., Pittsburgh, Pennsylvania 15206.*

SCIENCE FOR CONSERVATORS: CRAFTS COUNCIL CONSERVATION SCIENCE TEACHING SERIES (available from Crafts Council, 12 Waterloo Place, London SW1Y 4AU). **BOOK 1, AN INTRODUCTION TO MATERIALS** (1982), 112pp, illus., **BOOK 2, CLEANING** (1983), 128pp, illus., **BOOK 3, ADHESIVES AND COATINGS** (1983), 135pp, illus., £5.00 each. The problem in reviewing these three excellent books is that they are only the first half of a project which is unfinished and apparently likely to remain so. This is a great pity, as much care and thought have gone into their production and the complete set would have fulfilled the need for a standard introductory text on scientific principles in conservation for a long time to come. The understandable optimism with which the project was begun is reflected in the handsome design and in the colour sequence of the covers: red, orange and yellow. The covers of the remaining volumes were to have completed the spectrum on the conservator's bookshelf.

Nevertheless, there is much to commend in these three volumes and they should be required reading for all conservation students and indeed all conservators with little or no formal scientific background.

The aim of the series is to introduce conservators with no previous knowledge of science to the scientific principles which underlie fundamental conservation procedures. The editors have assembled an impressive team of authors and advisers, including scientists and conservators from major museums in Britain and also teachers well used to explaining difficult concepts in a straightforward fashion.

The task this team set themselves was a daunting one. To explain to other people concepts and principles which one normally takes entirely for granted is never easy. To simplify without trivializing is very difficult indeed, a difficulty, it must be said, not entirely overcome here. It is perhaps more a matter of tone than of content: there is a faint suspicion, especially in Book 1, that the reader is being patronized, emphasized by the constant use of the second person singular and a whimsical preoccupation with *Alice in Wonderland* with an extract from which each volume begins. In Books 2 and 3 a rather more impersonal style emerges which this reviewer, at any rate, prefers.

Book 1, *An Introduction to Materials,* is necessarily highly theoretical, but satisfactory links are made wherever possible to topics of direct interest to practising conservators (such as the chemical basis of the fresco process described by Cennino Cennini). The first chapter is a somewhat arbitrary but nonetheless stimulating account of 'what science is' including the broad classification of natural materials and, in a general way, their identification. At the end of this chapter is a useful section on measuring relative humidity, sensibly chosen to illustrate the significance of accuracy in making scientific measurements.

The rest of Book 1 is more or less pure chemistry, defining terms, introducing symbols, formulae and equations and bravely tackling atomic structure and chemical bonding. In explaining atomic and molecular orbitals, the authors are well aware of the deep waters they might stray into and present a simplified account of admirable clarity while hinting at the complexity which underlies it.

The final chapter concerns chemical nomenclature, distinguishing between trivial and systematic names and introducing the IUPAC system without actually referring to it as such. While far from comprehensive, it nevertheless serves as a valuable pointer to an area of knowledge vital to every conservator: confusion about chemical names is dangerous and widespread and a little basic training such as this would benefit many.

It is assumed that the principles set out in Book 1 are mastered before Book 2, *Cleaning* and Book 3, *Adhesives and Coatings* are read. With these the conservator may think him or herself on familiar territory but the approach is a novel and thoughtful one.

In *Cleaning,* for example, classification is not in terms of the nature of the object under treatment, which is the way a conservator would normally approach the subject, but in terms of the nature of the 'dirt' (whatever it is) and the methods used to remove it. These include mechanical techniques, organic solvents, water, acids, alkalis, other reagents and so on.

In these chapters the plan of the whole projected series becomes clear. Scientific principles are introduced when required and familiarity with them is assumed thereafter: thus topics in Book 3 rely on the understanding of concepts established in Book 2. The nature and properties of solvents, for instance, quite properly appear in the relevant chapters on cleaning, but are then developed further when adhesives and coatings are discussed in the next volume.

The selection and ordering of materials for Books 2 and 3 and, even more, the level of sophistication, must have been very difficult to decide. Most of the time the editors and authors have got it exactly right. Just occasionally one wonders whether a subject is approached in quite the right way, whether it goes far enough, or too far. One example is the somewhat laboured analogy between energy and money in Book 2: surely the people who will read this are intelligent enough to grasp the point about energy being conserved without flow charts of a conservator's income and expenditure? The analogy gets more complicated than the principle it is intended to illuminate.

Another example in Book 2 is the discussion of energy changes in solutions, clearly and sensibly set out in simple thermodynamic terms. Would it not, though, have been worth going just a little bit further and including solubility parameters? After all, they are mentioned in conservation literature relatively frequently and do alarm and mystify many conservators who might have been reassured to find even a mention here.

Book 3, *Adhesives and Coatings,* covers joining, coating and consolidation and the types and properties of materials required. The brief introduction to polymer chemistry, the examples of different adhesive types and the physical properties of materials are all excellently done. The chapters on coatings and consolidants are, by comparison, rather slight. Conservators of paintings, especially, will be disappointed that discussion of the refractive index of varnishes is deferred until Book 4, which may never appear.

If it is possible to identify a complaint about these three books, it is in the matter of references: apart from a couple of isolated footnotes, there are none.

Now, quite possibly this was to have been taken care of with a bibliography in Book 6 (projected title: *A guide to reading scientific papers, using sample texts*) but one wonders if this was the right approach anyway. If those footnotes were deemed essential in a couple of cases, then a general plan involving end-of-chapter references might have been better from the start.

However, the only major complaint will be if the publishers do indeed fail to complete the series. Meanwhile, they and their editors must be congratulated on producing three exemplary teaching volumes and encouraged to produce the others before the impetus is lost.—*David Bomford.*

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REVIEWERS

Special thanks are extended to the following for reviewing manuscripts:

P. Beelitz, E. J. Censky, G. Edmund, G. R. Fitzgerald, M. E. Genett, G. Harlow, M. Kaminitz, M. LeCroy, J. Levinson, H. G. McDonald, R. F. Miller, R. K. Panza, J. E. Rawlins, B. Rhodes, N. J. Root, C. L. Rose, L. Saul, J. B. Waddington, S. L. Williams.

ERRATUM

In the feature article, "Systematic collection curators as historic preservationists: Case studies from the MCZ Mammal and Bird Departments" (*Collection Forum,* 4(1):16–17), the two photographs of the nighthawk were printed with the wrong orientation. Wilson's original figure and photo by Coleman, as well as the photo by Purcell, were oriented head downward in the attitude of "booming" as is characteristic of this species. The photos should have been printed as such in the journal. Our apologies.

Preparation of Manuscripts

General.—It is strongly recommended that, before submitting a paper, the author ask qualified persons to appraise it. The author should submit three copies of the manuscript either typewritten or printed on letter quality printers. **All parts of the manuscript must be double spaced** with pica or elite type on 8½ × 11 inch (21.6 by 27.9 cm) or A4 paper and at least one inch (2.5 cm) margins on all sides. Manuscripts should not be right justified, and manuscripts produced on low-quality dot matrix printers are not acceptable.

Each page of the manuscript should be numbered. Do not hyphenate words at the right-hand margin. Each table and figure should be on a separate page. The ratio of tables plus figures to text pages should generally not exceed 1:2.

The first page includes the title of the article, names of authors, affiliations and addresses of authors, and the abstract if present. In the top left-hand corner of the first page, indicate the name and mailing address for the author to whom correspondence and proofs should be addressed. All subsequent pages should have the last names of the authors in the upper left-hand corner.

The preferred language for manuscripts is English, but a summary in another language can precede the literature cited, if appropriate. Manuscripts written in other languages will be considered if the language uses the Roman alphabet, an English summary is provided, and reviewers are available for the language in question.

Abstract.—An abstract summarizing in concrete terms the methods, findings and implications discussed in the paper must accompany a feature article. The abstract should be completely self-explanatory and should not exceed 200 words in length.

Style and abbreviations.—Symbols, units, and nomenclature should conform to international usage. Cite all references in the text by the author and date, in parentheses. Footnotes should be avoided. For general matters of style authors should consult the "Chicago Manual of Style," 13th ed., University of Chicago Press, 1982.

Literature cited.—This section includes only references cited in the manuscript and should be typed double spaced. References are listed alphabetically by authors' names and take these forms:

Jones, E. M., and R. D. Owen. 1987. Fluid preservation of specimens. Pp. 51–64 in *Mammal Collection Management* (H. H. Genoways, C. Jones, and O. L. Rossolimo, eds.). Texas Tech University Press, Lubbock, 219 pp.

Sarasan, L. 1987. What to look for in an automated collections management system. Museum Studies Journal, 3:82–93.

Thomson, G. 1986. The museum environment, 2nd ed. Butterworths, London, 293 pp.

Tables and illustrations.—Tables and illustrations should not repeat data contained in the text. Each table should be numbered with arabic numerals, include a short legend, and be referred to in the text. Column headings and descriptive matter in tables should be brief. Vertical rules should not be used. Tables should be placed one to a page, after the references.

All figures must be of professional quality as they will not be redrawn by the editorial staff. They may include line drawings, graphs or black and white photographs. All figures should be of sufficient size and clarity to permit reduction to an appropriate size; ordinarily they should be no more than twice the size of intended reductions and whenever possible should be no greater than a manuscript page size for ease of handling.

Photographs must be printed on glossy paper, with sharp focus and high contrast essential for good reproduction. Photos should be trimmed to show only essential features.

Each figure should be numbered with arabic numerals and be referred to in the text. Legends for figures should be typed on a separate sheet of paper at the end of the manuscript. Magnification scale, if used, should be indicated in the figure by a scale bar, not in the caption. Notations identifying the author and figure number must be made in pencil on the back of each illustration. All illustrations must be submitted as an original and two copies. Note placement of tables and illustrations in the margins of the manuscript.

Evaluation of a manuscript.—Authors should be aware that the following points are among those considered by the editorial staff when evaluating manuscripts: 1) Is the content appropriate to the purpose of the journal and society? 2) Are the contents clearly and logically presented and the paper well organized? 3) Is the methodology technically and logically sound? 4) Does the paper contribute to the body of knowledge and literature? 5) Is the study integrated with existing knowledge and literature? Is the literature cited appropriate for the study? 6) Are the conclusions supported by sufficient data? 7) Does the title reflect the thrust and limitations of the study? 8) Are the tables and figures clearly presented? Are they necessary to support the text?

Submission Procedure

Manuscripts intended either as feature articles or general notes should be submitted in triplicate (original and two copies) to the Managing Editor. Letters to the Editor and correspondence relating to manuscripts should be directed to the Managing Editor. Books for review should be sent to the Associate Editor for Book Reviews.

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