Appendix Q: Curatorial Care of Natural History Collections

Appendix Q: Curatorial Care of Natural History Collections

A. Overview

1. *What information is in this appendix?*

Many parks have Scope of Collections Statements that call for collecting and documenting natural history specimens from the ecosystems in parks. This appendix is a brief introduction to the care of a wide range of specimens found in natural history collections. It contains information about:

- the preventive conservation approach for natural history collections in general
- basic descriptions of the variety of specimens you may find in your natural history collections
- descriptions of the common collecting techniques that have historically been used for natural history specimens

Note: Refer to the glossary at the end of this appendix for the definitions of specific terms.

This appendix will **not** give you information on proper techniques for care and storage of natural history collections. Information on preventive conservation for each type of collection will be contained in Appendix T: Care of Biological Collections, Appendix U: Care of Geological and Paleontological Collections, and Appendix V: Care of Environmental Research Collections, to follow. These appendices will give you information on environmental standards, handling, storage techniques, and shipping natural history collections.

Also, this appendix will **not** tell you how to collect and mount specimens yourself. These are skills requiring specialized education and training.

Preventive conservation is the best approach to caring for the vast amount of scientific data resident in natural history collections. Understanding basic collecting and preparation techniques will help you to understand preservation problems specific to natural history collections.

2. *Why are natural history collections important?*

Natural history collections form the basis for our understanding of the world. Scientists use natural history collections to look at questions of evolution and global change. As non-renewable resources, natural history collections document disappearing habitats, species extinction, and disappearing geological and paleontological sites. Natural history specimens document the presence of a species at a specific place and time.

Research enhances the value of these collections. A vast number of questions can be asked about our parks and the environment using natural history collections. As collections are studied and used, the information generated expands our knowledge of the parks and their relation to the broader environment. Collections that have been used for research can be used to document work, confirm conclusions, and develop new interpretations.

3. *What is the purpose in preserving natural history collections?*

Curators and collection managers maintain natural history specimens so scientists can access these specimens in the future to answer questions about the natural world. Collections document change in the natural world. Each properly documented specimen is a unique historical and scientific record. Each natural history collection may be valuable for scientific research.

Preserving the information contained in specimens is the primary goal of natural history conservation.

Preserve each specimen so that scientists can use it to:

- verify past research
- complement or facilitate current research
- encourage and enhance new research in the future

Use preventive conservation to care for scientific collections and maintain them for research by scientists. Focusing on the research potential of these collections doesn't mean that you can't use them for exhibition or teaching. However, you should first consider the research potential of any specimen when making a decision about its care and use. Research on natural history collections is as diverse as the specimens themselves. Review the importance of NPS collection-based research in Chapter 1: NPS Museums and Collections.

4. *What is preventive conservation?*

A specimen with an unknown collection, preparation, and treatment history cannot be used with confidence for any research. A preventive conservation approach ensures the integrity of the specimens for research by introducing as little change as possible. Preventive conservation also improves specimen potential for use in exhibits and educational programming. For an introduction to preventive conservation, see Chapter 3: Preservation: Getting Started. For a discussion of "minimal intervention," see Chapter 8: Conservation Treatment.

A preventive conservation approach allows access to all collections while minimizing the risk of deterioration and loss. Use this perspective while collecting, preparing, and maintaining specimens. Follow the maxim: "minimal intervention – maximum documentation."

Do as little as possible to a specimen and record whatever you do completely and accurately. Record this information in:

- field notes
- ANCS+
    - preparation/treatment supplemental record
    - preservation supplemental record

Good documentation distinguishes conservation treatment from simple meddling. The documentation requirements for any conservation treatment are discussed in Chapter 8: Conservation Treatment, and the American Institute for Conservation (AIC) Code of Ethics and Guidelines for Practice in Appendix D**.**

Good storage design promotes preventive conservation. Effective storage designs improve access, minimize unnecessary handling, and properly cushion and support specimens. Good storage protects specimens from agents of deterioration, such as pests, light, improper or fluctuating temperature and relative humidity, and environmental pollutants. Use storage materials that will not interact with the specimens. For more information on safe storage materials see the *Conserve O Gram* (*COG*) series and NPS *Tools of the Trade*.

Active treatments should rarely be performed on a specimen preserved for research. By simply cleaning a specimen you may remove information. Stabilize damaged specimens by means other than active repairs. In contrast, specimens intended for exhibits and educational programming may require repairs for both stability and aesthetics. Repair may be acceptable when it will improve the durability and visual appearance of a specimen for the public.

5. *How can I find the latest information on the care of these natural history collections?*

You can find information on natural history conservation in a variety of sources. Because this is a new and rapidly evolving field, it's important to be aware of new information as it is published.

Sources of information:

- NPS *COG* series includes a section titled "National History Specimens." Watch for updated information.

- The Society for the Preservation of Natural History Collections (SPNHC), a professional organization, specifically supports collections management and preventive conservation for natural history collections. The organization publishes a newsletter and a journal, *Collection Forum*, with information on preservation of natural history collections. SPNHC has published two books that are invaluable resources for any park with natural history collections: *Storage of Natural History Collections: Ideas and Practical Solutions*, edited by Carolyn L. Rose and Amparo R. de Torres and *Storage of Natural History Collections: A Preventive Conservation Approach*, edited by Carolyn L. Rose, Catharine A. Hawks, and Hugh H. Genoways. You can find more information about SPNHC at <http://www.geo.ucalgary.ca/spnhc/>.

- Many natural history disciplines support professional groups that publish specialized newsletters and journals with articles on new research and techniques. See Section F for some of these publications.

- Information on the use of natural history collections can be found in *Museum Handbook*, Part III,*(MH-III)* Chapter 1, Section F.

6. *What other NPS documents give me information about natural history collections?*

There are a variety of NPS sources that contain policy and guidance on natural history collections. You should acquaint yourself with the information in the following documents:

- Chapter 1: Museum Collections, and Chapter 2: Scope of Museum Collections, discuss what kinds of collections (including natural history) you should collect and why.

- Chapter 4: Museum Collections Environment, and Chapter 7: Museum Collections Storage, discuss the building envelope and how it can protect your collections.

- Museum Handbook, Part II (*MH-II*), Chapter 4: Special Instructions, discusses compliance with the Code of Federal Regulations (36 CFR 2.5). This regulation states the conditions under which the superintendent may issue permits to collect natural history specimens. See especially Section VI, Complying with Regulations for Cataloging Natural History Specimens.

- *MH-II*, Appendix H: Natural History, describes cataloging and labeling natural history specimens.

- *MH-III*, Museum Collections Use, discusses research use on existing collections. In particular, see Chapter 1: Evaluating and Documenting Use, Section F, Scientific Issues.

- Special Directive 91-4, Ensuring that Natural Resource Projects Fund the Curation of Collections, provides guidance on cataloging requirements for collectors. A new *Director's Order #24: Museum Collections Management*, will replace this special directive.

- New guidance on research and collecting permits, application procedures and related forms has been published in the Federal Register.

- *Director's Order #28: Cultural Resource Management Guideline*, Chapter 9, Management of Museum Objects, discusses the importance of field notes and other archival and manuscript collections that may help document and interpret museum collections.

7. *Where can I find information about the hazards found in natural history collections?*

Information about hazards found in natural history collections is abundant. Hazards come from preparation, storage materials, pest control methods, or may be inherent in the specimens. To find information about hazards, look at:

- references listed under Health and Safety in Section G, Selected References

- Chapter 11: Curatorial Health and Safety

- NPS *COG* leaflets on a range of topics, especially Section 2, Security, Fire and Curatorial Safety, and Section 11, Natural History Specimens

- the Internet, starting with Conservation OnLine (CoOL) <http://palimpsest.stanford.edu>, which has a section on health and safety.

B. The Nature of the Collections

The specimens in natural history collections are often diverse and complex. Natural history collections may be:

- organic (such as birds and mammals)
- inorganic (such as rocks and minerals)
- organic/inorganic composites (such as shells, some fossils, and bone)

Specimens are collected from a vast array of natural environments. The one thing most natural history specimens have in common is that they are usually ***prepared*** before being added to the collection.

1. *What is preparation?*

Most specimens come to museums through field collecting. But, whatever their source, all specimens undergo some field and/or laboratory preparation prior to becoming part of a collection. Preparation may entail the skilled excavation of fragile fossils from the surrounding matrix, or the complex chemical fixation of biological tissues to stop putrefaction. Whatever the preparation method, the reason collectors prepare specimens is to make them accessible for research and other use.

Research and other specimen use vary considerably depending on the collector. Research questions have changed historically. For these reasons specimens of the same kind (for example, bird study skins) may have been prepared by a variety of methods.

For biological collections, most basic preparation is done in the field within hours of the collection of the specimen. This ensures that they will not deteriorate before being taken to the laboratory for final preparation, analysis, and storage. Geological and paleontological collections are prepared both in the field and in the laboratory depending on the particular collecting environment and the needs of the specimen.

After preparation, a specimen may consist of several parts. For example, a small mammal specimen may become a study skin and a separately cleaned and stored skull, while the remainder of the body may be stored in fluid. A matrix formed of various rocks and other minerals may surround a mineral specimen. Parts of the mineral specimen or its matrix may be prepared as separate specimens or as mounts for microscopic examination. You should be aware of the importance of diverse kinds of preparation techniques in natural history collections.

2. *Are there standards for preparation?*

There are no standards for preparation that apply to all specimens. The type of preparation depends on a variety of factors including:

- the kind of specimen
- intended research or other use of the specimen
- skill, experience, and research interest of the collector

- tradition
- available resources

In addition, there has been little research into the chemical and physical effects of many types of preparation. Because of all these issues it is impossible to develop a servicewide standard for preparation of an individual species. **There is no one right way.**

You can work with researchers during the permitting process to request that they use preferred techniques for your collections. See *NPS-77*: *Natural Resources Management Guideline*, Chapter 5, Program Administration and Management. For example, you can request that a collector use standard-sized glass jars with polypropylene lids lined with polyethylene for vertebrate specimens preserved in fluid. Be aware, however, that certain research issues may require that the scientists use different preparation techniques.

The natural history collection appendices following this one discuss the storage and care issues involved in the long-term preservation of natural science collections. You can use these requirements to help develop preferred preparation techniques for your collections.

3. *What kinds of natural history materials are particularly important?*

There are two kinds of materials that are especially important:

- **Type specimens** are the most important specimens in natural history collections. There are many categories of type specimens. The most important are the name-bearing types. ***Taxonomy*** is the discipline devoted to the identification, naming, and classification of organisms. Biological specimens are divided into scientific categories called ***taxa*** (singular taxon) and given specifically defined names (known as nomenclature codes). The biological sciences use Latin names rooted in the classification system begun in the 18th century by Carl von Linne (Linneaus). Mineralogy uses a system evolved from the 19th century work of James and Edward Dana. Researchers in both the geological and biological sciences use the concept of the "type."

  Type specimens must be designated in the first published description of the taxon. These are the specimens that are designated as the bearers of the scientific name of a taxon. Name-bearing types serve as international standards of reference in taxonomy. Scientists examine type specimens to verify identifications and to revise taxonomic classifications.

  The ***holotype*** is the most important name-bearing type. A holotype is the single specimen that is designated as the type in the first published account of a newly described taxonomic group. The account must be published in an appropriately reviewed scientific book or journal. There are a variety of other name-bearing types that are defined by the different scientific disciplines.

  Museums hold type specimens in trust to ensure their safekeeping, and equally importantly, their accessibility for research. **Type specimens are considered to be the property or heritage of the scientific community.** The scientific community considers it unethical for institutions to keep type specimens if they cannot adequately manage and preserve them.

- **Documentation** that accompanies scientific collections is as important as the specimens themselves. You should be sure to gather all documentation and data from the collector and incorporate it in museum collections along with the specimens. Section C discusses the wide variety of documentation that can be important to natural history collections. Labels or tags attached directly to specimens should be considered part of the specimens. Refer to Section E for more information on the care of labels and tags.

C. Natural History Collections

This section briefly lists and describes the variety of materials in natural history collections. It also briefly describes how collectors prepare and store specimens of different materials. The types of collections are broadly divided into four groups:

- biological collections
- geological collections
- paleontological collections
- environmental research collections

> ***Specimens also have scientific documentation that is part of the park's archival collections*.**

1. *What kinds of specimens will I find in biological collections?*

Biological collections contain a wide variety of once-living specimens. Park biological collections document local ecosystems and their changes through time. This historical documentation is important to evaluate the effects of park policies on the natural environment. These specimens are divided in a variety of ways, which may vary from collection to collection. For example, invertebrates are separated between entomological (insect) collections and other invertebrate collections (such as mollusks or crabs).

The main divisions are:

- botanical specimens (plants)
- entomological specimens (insects)
- other invertebrate specimens (species with no backbone or spinal column)
- vertebrate specimens (species with a backbone or spinal column)

Examples of the types of specimens found in each of these types of collections appear below.

Microorganisms (bacteria, yeast, protozoa, viruses, diatoms, etc.) may be collected in parks, but are rarely, if ever, deposited in park collections at this time. They have very specific and technical care requirements that require specialized repositories. For more information on biological specimens, contact specific discipline specialists and refer to *MH-II*, Appendix H: Natural History.

2. *What groups of species will I find in botanical collections?*

Botanical collections contain a wide range of material. The more common groups are:

- bacteria
- algae
- mosses and liverworts
- clubmosses
- horsetails
- ferns
- conifers and other evergreens
- flowering plants
- fungi

See the *MH-II*, Appendix H: Natural History, for a complete list.

3. *What kinds of specimens and preparations will I find in botanical collections?*

Botanical specimens have been collected and stored in diverse ways. Variations depend mostly on the physical characteristics of the specimens but also on their intended use. These include:

- dried plants on herbaria sheets
- dried specimens, or partial specimens, or dissected parts in packets (fragment folders) sometimes attached to herbaria sheets
- lichens and mosses, dried and stored in folded paper or glassine packets and sometimes attached to herbaria sheets or stored in boxes
- dried specimens in boxes – large fungi, wood samples, pine cones, and generally anything dry that is too large for a packet and too bulky for a herbarium sheet
- specimens in fluid – often cacti and other succulents, or flowering plants, fruits, or other specimens where pressing would be difficult or desiccation would destroy tissues of interest, including diatoms, slime molds, fungi, algae, and phytoplankton
- wood samples
- seeds (sometimes in cold storage)
- pollen

- economic botany collections – agricultural seeds, cultivars that are dry or in fluid, plant products
- freeze-dried display specimens
- plant models – display or teaching models in a variety of materials
- living collections
- DNA/RNA extracts
- various microscopy preparations – stained tissues, scanning electron microscope (SEM) stubs or mounts

4. *What groups of species are in entomological collections?*

Park entomological collections contain invertebrates such as insects and arachnids.

- arachnids – mites, scorpions, spiders, ticks
- insects – ants, beetles, bedbugs, bees, butterflies and moths, cicadas, cockroaches, crickets, damselflies, dragonflies, earwigs, fireflies, flies, gnats, grasshoppers, leafhoppers, lice, mantids, mosquitoes, termites, wasps, water boatmen, and weevils, etc.

This is an incomplete list. See *MH-II*, Appendix H, for a more complete list of entomology specimens.

5. *What kind of specimens and preparations will I find in entomological collections?*

You will find entomological collections as:

- pinned specimens – including spread-wing specimens
- specimens on points – specimens mounted on paper or other materials attached to pins
- specimens in fluid – usually alcohol or formaldehyde
- specimens in envelopes or folded packets
- microscopy preparations
- eggs, egg cases, and cocoons (wet or dry)
- larvae and pupae (wet or dry)
- nests
- living entomology specimens (to study life cycles)
- economic entomology collections – species that inhibit or foster agriculture or health, pest species, products from insects

- cultural or art objects derived from insects that are cataloged under cultural resources and cross-referenced to park entomological collections —for example, a necklace decorated with an amber-trapped insect

6. *What groups of species will I find in other invertebrate collections?*

Invertebrates are animals without backbones or spinal columns. Entomological collections in parks are usually separated from the other invertebrate collections. These other collections have specimens from both land and water (terrestrial and aquatic) environments.

- brachiopods, corals, crustaceans – for example, lobsters – and a few other classes from the phylum Arthropoda
- echinoderms – for example, sea urchins
- mollusks – for example, snails
- sponges
- worms

7. *What kind of specimens and preparations will I find in collections of other invertebrates?*

Invertebrate specimens may be stored as:

- dry specimens – mollusk shells, corals, most echinoderms, exoskeletons of some crustaceans
- specimens in fluid – mollusks with or without shells, brachiopods, crustaceans, plankton, sponges, worms
- specimens or specimen parts as microscopy preparations – mounts from Scanning Electron Microscope (SEM) preparations, mounts on microscope slides, sections of shells
- shell art and craft objects that are cataloged under cultural resources and cross-referenced to park invertebrate collections

8. *What groups of species will I find in vertebrate collections?*

Vertebrates are animals with spinal columns or backbones. Vertebrate collections often include:

- amphibians – for example, frogs
- birds
- fishes
- mammals
- reptiles – for example, snakes

9. *What kinds of specimens and preparations will I find in vertebrate collections?*

Vertebrate specimens may be stored as:

- study skins – untanned skins filled with fibrous materials to approximate the shape of an animal; may contain some skeletal material

- flat skins – tanned or untanned
- taxidermy specimens
  - mounted skins – tanned or untanned skins on mannequins, positioned in a life-like manner; may also contain some skeletal material
  - trophy heads – mounted tanned or untanned skins, sometimes with horns or antlers
- spread wings of birds – dried, untanned, with bones in wings
- naturally mummified specimens
- freeze-dried specimens – complete specimens, or gutted specimens with some fibrous fillings
- fluid-preserved specimens – whole or partial specimens including embryos, larval fish, and some eggs; also includes cleared and stained specimens, such as specimens that have been chemically prepared to be transparent
- skulls
- post-cranial skeletons – articulated, partially articulated, and artificially articulated
- whole skeletons
- dissected parts preserved dry
  - bacula (the penis bone)
  - sectioned teeth
  - stomach contents
  - otoliths (a layered calcium concretion found in the inner ear)
  - hyoids (a bone or a structure formed from cartilage located at the base of the tongue)
  - scutes (plates or shells from armadillos, turtles, tortoises)
- frozen whole specimens – incoming material awaiting processing
- frozen tissues – usually organs preserved for molecular analysis
- scats (dried fecal material)
- regurgitated pellets

- casts, molds, and peels
  - teeth
  - skulls
  - marine mammals
  - fish
  - some reptiles and amphibians
  - animal tracks
- whole eggshells and fragments – bird, mammal, or reptile
- nests – bird, mammal, or reptile
- feathers
- various microscopy preparations
  - SEM mounting stubs
  - tissue sections
  - parasites – both internal and external
- tissues for DNA/RNA extraction
- DNA/RNA, nucleic and amino acids, and other materials extracted from tissues
- feather art (objects crafted from feathers, where the feathers are of interest to scientists)
- animal skin rugs or other objects where the skins are of interest to scientists

10. *What groups of specimens will I find in geology collections?*

Geology collections document geological processes and materials. They can be divided in the following overlapping material types:

- rocks
- surface process materials
- minerals
- organic materials

- extraterrestrial materials
- soils

11. *What kind of specimens and preparations will I find in geological collections?*

Geological collections often contain:

- minerals
- biominerals – amber, pearls, and other materials considered to be minerals that are derived from biological process, such as those in bone and shell
- synthetic minerals
- gems
- rocks
- powders
- drill cores
- frozen specimens – samples of ice or ice cores
- ore samples
- mining concentrates
- soil samples
- products from industrial minerals
- petrology specimens
- meteorites and other materials of extraterrestrial origin
- fossils – collected for mineral content
- various microscopy preparations – thin sections, micromounts, X-ray diffraction mounts, SEM mounting stubs
- jewelry and lapidary art that are cataloged under cultural resources but cross-referenced to park geology collections

12. *How are geological specimens stored?*

Most geological specimens are preserved dry and in a normal oxygen environment. A few minerals require desiccated environments. Some minerals are stored in fluids. Meteorites and other extraterrestrial samples are preserved in specialized gaseous environments. Some radioactive specimens may require specialized housings. There are also a number of light sensitive specimens that should be stored in the dark at all times. For more information on storage and housing of geological specimens, see *COG* 11/2, "Storage Concerns for Geological Collections," and Appendix U: Paleontological and Geological Collections.

13. *What groups of specimens will I find in paleontological collections?*

When considering paleontology collections, most people think of dinosaurs. However, a wide range of plants, insects, invertebrates, and vertebrates will be found in paleontological collections. All ancient biological organisms may be fossilized or preserved in some other manner. For a complete list of paleontology specimens see *MH-II*, Appendix H: Natural History, Paleontology.

14. *What kinds of specimens and preparations will I find in paleontological collections?*

Paleontological collections may include:

- frozen specimens – collected from permafrost areas
- mummified specimens
- vertebrate and invertebrate body fossils
- plant and seed fossils
- trace fossils
- vertebrate and invertebrate sub-fossil specimens (specimens still retaining organic material)
- compression fossils (organic remains flattened by the pressure of soil and rock above)
- mounted skeletons
- reproductions made for study or exhibits – casts, molds, peels
- palynology specimens (pollen)
- specimens in fluid – for example, microfossils in glycerin
- fossils sliced into sections
- specimens in jackets (field material still encased in the plaster or other materials used to protect them during shipping to the museum)
- soil samples – often intended for processing to remove small fossils
- amino acids, DNA, and other materials extracted from specimens

15. *How are paleontological specimens stored in collections?*

Most paleontology specimens are preserved dry, in a normal oxygen environment. Paleontological specimens are often removed from the field in plaster jackets. Before and after preparation, these specimens are stored on shelves or in cabinets. Some microfossils are stored in glycerin or other fluids. Be aware of any radioactive paleontological specimens and use cabinets vented to the outside to store these materials. See *COG* 2/5, “Fossil Vertebrates as Radon Source: Health Update.”

16. *What kinds of materials are in environmental research collections?*

Environmental research collections are specimens, samples, and analytical data collected to monitor levels of various elements and compounds in the environment. Environmental research may result in composite samples, such as water, precipitation, air, and sediment. They are classified separately from biology, geology, and paleontology collections because they are often mixtures of materials collected to study specific environments. For example, a water sample may be collected to study biota.

Some of the specimens and samples require extremely rigorous collecting, storage, and handling procedures to ensure specimen integrity for trace element or other analyses. For example, the National Institute of Standards and Technology, in conjunction with the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service, has developed the National Marine Analytical Quality Assurance Program. Part of this program includes specimen banking (storage of specimens under very controlled, known conditions) to permit analysis of changes in marine environments over time.

17. *What kind of specimens and preparations will I find in environmental research collections?*

The variety of materials you may find in environmental research collections includes:

- biological tissues (in ultra-cold storage)
- soil samples
- water samples
- air samples
- air or water filters
- recording charts from analytical instruments – air, noise, water quality
- eggshell and mollusk shell samples
- other specimens or specimen parts collected according to special protocols

Chapter 2: Scope of Museum Collections, discusses environmental research samples in your scope of collection statement. For a discussion of how these specimens should be cataloged see *MH-II*, Appendix H: Natural History.

18. *What kinds of documentation are associated with a natural history collection?*

In some collections, the documentation is considered to be part of the specimen. Color images made when the specimen was collected are especially important. The National Park Service catalogs these collections as archival collections. The variety of materials used in documenting specimens include:

- original catalogs
- field notes
- locality maps (with handwritten notations)

- card files on various topics
- sampling/dissection records
- charts and graphs produced by analytical instruments
- computer tapes/disks
- original sketches/drawings/watercolors or other paintings
- plates or prints
- photographic records – slides or transparencies, prints, negatives, X-radiographs, prints and negatives of X-ray diffraction patterns and autoradiographs, motion picture film, videotapes, CD-ROMs
- sound recordings – reel-to-reel tapes, cassette tapes, phonograph records, compact disks

Other official records associated with natural history collections include:

- permit files and accession and catalog records (including catalog folders with copies of detached specimen labels)
- loan files
- condition records
- offprints of research articles based on the specimens
- exhibit catalogs featuring specimens
- books and periodicals

D. Collecting and Preparation Techniques.

1. *What are preparation techniques?*

Collectors use preparation techniques to prepare specimens for research and storage. These methods focus on the short-term preservation of the specimen. Preparation techniques achieve a particular purpose for research or public programming use of the specimen. Unfortunately, little research has been done to understand how interactions between the specimen and preservative chemicals or other preparation methods affect long-term preservation. Therefore, few preparation methods can be said to be either “right” or “wrong.” The effects of preparation and storage techniques are areas of active research. Keep abreast of current literature to be aware of changes in methods. Recommendations may change rapidly.

Literally hundreds of chemical formulas, materials, and techniques have been applied to specimen preparation over the past three centuries. Collectors still use many of these techniques. The methods vary according to:

- the kind of specimen – bird, mammal, fish, amphibian, reptile, plant, mineral, fossil
- the primary purpose for which the specimen is collected – research, education, exhibit
- the specific research purpose for which the specimen is collected – gross anatomy, histology, classical taxonomy, biochemical analysis, crystallography, trace element analysis
- the skill and preference of the collector or preparator
- project budget and staff resources

Talk to discipline-specific researchers to gain an understanding of the preparation techniques commonly used on the specimens in your collection. The information given below describes the most common preparation methods. This overview may assist you in requesting adequate data when you accession new collections. The methods are divided into sections on dry collections, freeze-dried specimens, fluid-preserved materials, specimen labels, and labeling techniques.

2. *What documentation should I keep on preparation techniques?*

You should acquire information on the collecting and preparation techniques used for each specimen. Get this information at the same time the park accepts the specimens for the museum collection. The 1988 article by Gerald R. Fitzgerald, "Documentation Guidelines for the Preparation and Conservation of Paleontological and Geological Specimens," and the 1989 article by Kimball Garrett, "Documentation Guidelines for the Preparation and Conservation of Biological Specimens," provide excellent surveys of the topics of importance. In addition to information on the condition of the specimens at the time of treatment, these guidelines recommend that you obtain documentation on:

- field collecting and shipping techniques – Was the specimen captured (trapping, netting, killing methods) or salvaged (roadkill)? If it is a fossil or mineral, what were the excavation, packing, and transport methods?
- initial treatments – cleaning, freezing, drying, pressing, fixation, coating or application of other preservatives, jacketing materials, and delayed shipments of frozen material
- initial laboratory treatments on arrival at a museum or other collecting institution
- post-collection treatments of specimens – fumigation, degreasing, fluid changes, cleaning, matrix removal, consolidation, coatings, filling gaps, pest-proofing, restoration, repair
- specimen analyses – X-radiography, dissection, molding and casting, sampling, or other procedures that are likely to have an impact on specimen condition

Record this information in ANCS+ in the Preparation/Treatment associated module.

When specimens deteriorate, there is no way to evaluate the impact of their preparation history on that deterioration unless there is documentation on preparation methods. Hundreds of references on preparation methods have been published. However, there are few records that link a specific treatment to a specific specimen. This void in the documentation of specimens limits their utility for research, exhibition, and educational programs.

A scientist must know how a specimen was treated to decide if it is appropriate for current research. For example, scientists may choose not to do biochemical analysis if a specimen has an unknown history. Also, be careful about using a specimen with an unknown history for open display or in hands-on educational programming. Many long-lived toxic chemicals have been used in specimen preparation and in subsequent treatments of specimens for various purposes.

3. *How do collectors prepare dry botanical specimens?*

Collectors use a variety of techniques to prepare botanical specimens. You may find a range of methods in your older collections. Appendix T: Care of Biological Specimens, describes current NPS standards for collecting and storage. Often, specimens are just collected and pressed. Collectors may kill botanical specimens with a fluid – alcohol or petroleum. These fluids also help to remove water from the specimen. Specimens may also be cut open, boiled or salted, or dried/preserved with alcohol or alcohol vapor prior to pressing. It was common in the past to treat nearly every specimen with chemicals to control insects and microorganisms. Today, collectors more often use heat treatments or freezing.

Specimens to be mounted on herbaria sheets are sometimes washed in the field. To dry and flatten the specimen the collector puts it under pressure between sheets of paper, sometimes with heat. Back at the museum, a preparator mounts pressed specimens on paper or, if the specimen is bulky, on board. If you mount herbarium specimens, buffered, acid-free paper or board should be used. Mounting methods include:

- using strips of cloth, polyester film, or paper attached with adhesive
- using strips made with heat set tissues (a pure cellulose lens tissue impregnated with a heat setting adhesive)
- using adhesive alone, either under the specimen, or as straps
- sewing the specimen to the paper or board with thread

Many materials for mounting herbarium specimens are listed in NPS *Tools of the Trade*.

Packets of paper or glassine are used to store some specimens. Samples that collectors may place in packets and attach to sheets include: microscopy samples, dissected parts, seeds, some fruits, delicate parts of some ferns, and some other easily damaged specimen parts. Microscope slides and photographs are often placed in packets on sheets. Collectors attach labels and packets of fragments with a variety of adhesives.

Collectors sometimes dry bryophytes (mosses, liverworts, hornworts) and fungi with gentle heat. They may cut up fungi to speed drying. In humid field conditions the collector may store fungi and bryophytes over a desiccant chemical (such as calcium chloride) after drying. Fungi are particularly susceptible to insects. They are usually treated with a fumigant or are frozen or heated prior to introduction into a collection. In contrast, bryophytes are not particularly attractive to insects. Pest control chemicals can damage bryophytes. Therefore, collectors keep these specimens as dry as possible and don't contaminate them with fumigants.

Collectors usually store fungi and bryophytes in packets. Fungi packets rarely are attached to sheets; bryophytes are usually attached to sheets. Bulky fungi may require storage in boxes. Fragile species may require small boxes or trays inside the packet.

Some large or bulky botanical specimens are housed in polyethylene bags after drying. Bags, containing various parts of the same specimen, are supported on a mat board the size of a standard herbarium sheet. The entire assemblage is then placed inside another polyethylene bag. Very large specimens may simply be housed in a polyethylene bag. Specimens stored in this fashion must be very dry to avoid fungal growth in the bags. Large palm fronds and conifer branches are candidates for this type of storage.

4. *What problems might I see with dry botanical specimens?*

There are a variety of problems you may see in dry botanical specimens:

- Fragments may be lost from fragile specimens.
- Damage may occur from poor handling techniques and storage.
- Adhesives used by collectors may become acidic, discolor, fail, or shrink, causing damage to the specimens or labels.
- Paper and glassine used for packets may be acidic or may become acidic over time.
- Mold growth may occur on acidic, deteriorating glassine, which tends to be hygroscopic.
- Mold growth may occur on improperly dried specimens.
- Insects may damage the specimens.
- Migration of pesticides may stain herbarium sheets.

Many specimens have been treated with chemicals that may be health hazards or cause damage to the specimen. (See *COG* leaflets 3/12-3/14 concerning problems caused by the use of a variety of fumigants.)

5. *How do collectors prepare dry entomological specimens?*

Collectors use a variety of techniques to prepare entomological specimens. You may find a range of methods in your older collections. Appendix T: Care of Biological Specimens describes NPS standards for curatorial care.

Collectors kill entomological specimens with a chemical vapor or by dropping them in alcohol. They pin small specimens immediately. Other specimens are stored in alcohol or triangular glassine or paper packets.

Sometimes collectors relax specimens in a high humidity chamber (with a chemical to control mold) before spreading and mounting them.

Normally, collectors pin specimens through the right side with stainless steel or coated metal pins. The exact pin placement is governed by the position of the segment at the base of the wings. Sometimes collectors will mount them by first adhering the specimen to a paper or plastic point. Poor quality paper, archival paper, and Mylar or acetate films have all been used as points. Thin, dried strips of fungus, *Polyporus*, have also been used.

Collectors use a variety of adhesives to attach specimens to points. The points are then mounted on pins. Labels are commonly pinned below the specimen using the same pin. Collectors will often dry pinned specimens with low heat in an oven. Specimens removed from fluid may be dried in a critical point dryer. The technique involves dehydrating the specimen in acetone, placing it in a chamber filled with acetone, pumping liquid carbon dioxide into the chamber to replace the acetone, then heating the chamber to the critical point at which the liquid carbon dioxide becomes a gas. With moderate additional heat, the specimen dries completely.

6. *What problems might I see with entomological specimens?*

There are a variety of problems you may see in dry entomological specimens. These include:

- Virtually all specimens are exposed to fumigants or other chemicals at some stage in shipping and/or preparation. Some of these materials remain toxic indefinitely. Today, entomologists most commonly use paradichlorobenzene. You may see crystals of paradichlorobenzene and napthalene on the specimens or in specimen containers. Because of health and safety concerns about toxicity, this and any other fumigant you use must be approved through your IPM coordinator. See Chapter 5: Biological Infestations.

- Pins with slippery surfaces can yield specimens that “spin,” or turn on the pin.

- Old specimen pins often contain copper or nickel in the alloys. These metals can react with fatty acids in the specimens to produce fibrous blue or green corrosion products.

- The collector may have used unstable papers, films, or adhesives when attaching insects to points.

- Unmounted specimens in paper or glassine packets are often vulnerable to insect pests because they are not yet enclosed in the tightly sealed, glass topped boxes (such as the Cornell-style drawers available through NPS *Tools of the Trade*) that are used to house most pinned insects.

- Damage may be caused by poor storage and handling practices. Sometimes broken body parts will be glued onto a label.

Refer to Appendix T: Care of Biological Collections, for information on preventive care of entomological collections.

7. *How do collectors prepare dry invertebrates?*

Some invertebrates are simply dried. Collectors may also immerse invertebrates in formaldehyde, alcohol, or other solutions. These techniques either kill the animal or work as fixatives. Calcareous materials (shells, corals, echinoderm spines) immersed in formaldehyde and improperly rinsed may be prone to “Byne’s Disease.” This is a mineral efflorescence that results from the reaction of organic acids, such as formic and acetic acids, with a calcium-based substrate. Byne’s Disease usually gives a white powdery appearance to the surface of specimens.

Refer to Appendix T: Care of Biological Collections, for information on preventive care of invertebrate collections.

8. *How do collectors prepare dry vertebrate skins?*

Collectors routinely preserve birds and mammals as dry study skins. In contrast, dry skins of fish, reptiles, and amphibians rarely are preserved in research collections. To prepare study skins, collectors remove the skin from the specimen, treat it with absorbents, and fill it with fibrous materials. The filling is usually cotton batting (although a great many plant fibers and fine sawdust were used in the past). Modern collectors sometimes use polyester batting. Preparators use thin wooden supports inside bird specimens. In mammals, preparators use various types of wire to support the legs and tail. Labels are attached to the hind leg of the specimen with cotton or linen thread. In the past, specimens often were treated with chemicals during their processing. This is less common today, although collectors often rinse mammal skins in alcohol as part of the preparation process, and many collectors use sawdust, cornmeal, or other absorbent materials to facilitate drying. Study skins may be dried with heat. Today, birds sometimes are shipped in dry ice, stored in freezers, and prepared in museums. Collectors usually prepare mammals and birds in the field.

Collectors may dry large flat skins of vertebrates in the field, salt the skins, and later stabilize them using a variety of tanning processes. Sometimes collectors prepare the skins of small vertebrates as untanned flat skins. In this process, they remove the skin from the animal and then pin it to dry in a flat position. They may use absorbents in the skinning process and rinse small skins in alcohol prior to drying.

Taxidermy mounts and trophy heads can be extremely complex. A taxidermist may mount virtually any vertebrate. Taxidermists sometimes tan skins, but often they simply place a skin in a chemical solution to soften it. Once it is flexible enough, they manipulate it over a mannequin and let it dry in place. Mannequins may be bundles of fibrous materials, or a hard body constructed of plaster, fiberglass, or other easily formed materials. An internal armature of wood or metal supports the mannequin. Leg bones, or other skeletal material, and the skull may be used in the mounts. Other techniques used in mounting specimens include freeze-drying (see below).

Sometimes vertebrate shells or plates (scutes) and reptile and amphibian skins are dried and kept in collections. This is no longer a common practice and specimens prepared this way in the past were often treated with pest control chemicals during processing. Scutes are especially likely to have been treated with long-lived toxic materials. In some cases, the skins may have been tanned. Most often, they were prepared as untanned flat skins or were stuffed with any of a variety of fibrous materials.

9. *What problems might I see with traditional mounting techniques?*

There are a variety of problems you might see in specimens prepared using traditional mounting techniques:

- Arsenic and a number of other toxic compounds were used in the preparation and post-preparation treatment of taxidermy specimens. See *COG* 2/3, "Arsenic Health and Safety Update," for information on handling and use of these specimens. Commercial taxidermists may regard their materials and processes as proprietary and often are reluctant to provide detailed information. Tanned skins are rarely

  treated with pest control chemicals because the tanning processes render the skins fairly unattractive to insects and reasonably resistant to mold.

- Study skins of vertebrates with long tails and mammal specimens prepared with ears in upright positions are vulnerable to mechanical damage during storage and handling.

- Metal support wires used in specimens may corrode over time. Because the corrosion products have a greater volume than the original metal, the corrosion process often tears the skins. Metal armature in taxidermy mounts and wires in study skins may be copper or nickel alloys that will produce fibrous, blue or green corrosion products when they react with the fats in skins.

- The skins on taxidermy mounts are under great stress because the skins often shrink tightly to the form during drying. As a consequence, removing mounted specimens from their original stand changes the distribution of the stress, often causing the skins to tear or distort.

Refer to Appendix T: Care of Biological Collections, for information on preventive care of vertebrate collections.

10. *How do collectors prepare skeletal material?*

- Collectors may remove skulls and skeletons from specimens when fresh, after freezing, and occasionally from fluid-preserved specimens. They first remove much of the flesh from the bone. They then clean the specimens using a variety of techniques including:

- enzyme solutions

- maceration (with and without heat, detergents, ammonia, or bleaches)

- burial in sand, soil, or manure

- dermestid beetle colonies

After any of these treatments, further rinsing and some hand cleaning may be necessary. If cleaned by beetles, the specimens usually are fumigated, frozen, or rinsed in alcohol to kill the insects. Then the bones may be soaked in ammonia or chlorine bleach solutions to deodorize. The resulting specimens are then dried (with or without heat). Bones from large animals like bears may be degreased using organic solvents or alcohol. Sometimes large long bones are drilled and the marrow is removed to reduce the potential for migration of fats and oils out of the bone.

Fish skeletons may be removed from frozen specimens and cleaned with enzymes. Sometimes preparators stain the bones with an organic dye and store them in glycerin solutions.

11. *What problems may arise with skeletal material?*

Bone and teeth frequently deteriorate in vertebrate collections. Therefore, try to get documentation on exactly what processes preparators have used on bone. Bone is an organic/inorganic composite material. This means that the organic components are intimately mixed with the inorganic components and help to reinforce them and give them a certain flexibility. There are a variety of problems you might see in skeletal specimens.

- Prolonged maceration, enzyme solutions that have not been properly neutralized, and ammonia and chlorine bleach solutions that have a high pH degrade proteins, the primary organic reinforcement in bone and teeth, leaving the specimens brittle.
- Heat may also denature the protein.
- Acidic solutions attack the inorganic part of the composite, leaving bones soft and easily distorted.
- Poor storage and handling can damage bone causing cracking, abrasion and breakage. Low humidity in storage environments will cause cracking, especially to teeth.
- Numbers that have been written directly on the bone with indelible ink cannot be removed.

Refer to Appendix T: Care of Biological Collections, for information on care of skeletal material.

12. *How do collectors prepare freeze-dried specimens?*

Almost all types of biological specimens have been freeze-dried for exhibit purposes. After the specimens are frozen, the water is removed from them using vacuum sublimation. Specimens may be treated with a variety of chemicals as preparation for freeze-drying. After processing, preparators may use other materials to enhance specimen appearance. Large animals are difficult to freeze-dry, so these are often eviscerated before freezing. After freeze-drying, the specimens are stuffed with fibrous materials.

13. *What problems might I see with freeze-dried specimens?*

The loss of bound water makes freeze-dried specimens extremely fragile. For an excellent review of the problems of freeze-dried specimens see, "The Effects of Freezing and Freeze-drying on Natural History Specimens," by Florian (1990) listed in the Section G, Selected References. Because freeze-dried specimens are vulnerable to rehydration, especially at relative humidity above 40%, they can rot. It is important that you keep them in dry environments. Freeze-dried specimens are especially attractive to insect pests. Place these specimens in tightly sealed cabinets to prevent pests from getting into exhibit and storage cases.

Freeze-dried specimens are often used in NPS exhibits. These specimens are extremely vulnerable to insect attack and may be damaged or destroyed, requiring replacement. If you have freeze-dried specimens on display be sure to use good Integrated Pest Management (IPM) strategies to protect them. See Chapter 5: Biological Infestations, for information on developing an IPM plan.

Refer to Appendix T: Care of Biological Collections, for information on care of freeze-dried specimens.

14. *How do collectors prepare fluid-preserved specimens?*

A fluid-preserved specimen is "fixed," that is, treated with a chemical that causes some cross-linking of cell proteins. Then the specimen is stored in either the original fixative or in a chemical that preserves the fixed tissue. Collectors use a wide variety of chemicals for both processes. Sometimes specimens are not fixed prior to placing them in storage solutions.

Often, you will find small to moderately sized fluid-preserved specimens stored in glass bottles or jars. Large specimens are usually stored in tanks made of a variety of plastics or metals. Occasionally, plastic or metal liners are used inside a wooden frame or box. Collectors mount very tiny specimens on microscope slides or in small glass or plastic vials. Sometimes small containers are grouped inside larger glass containers.

In *botanical* collections perhaps the most common fixative is a solution called formal acetic alcohol (FAA). It is a mixture of formaldehyde (formalin), ethanol (ethyl alcohol), and glacial acetic acid in various proportions. A number of other fluid compositions have also been used. Instead of formalin fixatives, some preparators use alcohol as a preservative or a mixture of ethanol (with or without some methanol), water, and glycerin. There are a number of fixative/storage solutions, many of which contain glycerin.

In *entomology* ethanol is the most common fixative and preservative fluid in entomology. Sometimes other chemicals have been added to ethanol in an effort to preserve color or relax specimens.

Vertebrate specimens are usually fixed in buffered formalin and then preserved in alcohol. Numerous alkali neutralizers or actual buffers may be used in the formalin. Ethanol (70%) is the preferred storage fluid for mammals and birds. Fish, reptiles, and amphibians are stored in various concentrations of isopropanol (isopropyl alcohol) or ethanol. Numerous compounds are used for color preservation in vertebrate specimens. Preparators may have added these to any specimen.

15. *What problems may occur with fluid-preserved specimens?*

The container, closure, and gasket may react with the specimens or the fluid. Ask the donor what kinds of containers were used to house the specimens from the time they were collected. The storage solvent will evaporate over time and have to be replaced. Prior to fixation, collectors sometimes freeze specimens. This often leads to poor quality fixation and preservation.

Solvents used to store fluid-preserved specimens may gradually soak out lipids, proteins, and pigment over time, causing the solution to become discolored or cloudy. Labels printed on poor quality paper may deteriorate. The metal closure on flip-top jars may corrode.

Refer to Appendix T: Care of Biological Collections, *COG* 11/3, "Storage Concerns for Fluid-Preserved Collections," and 11/4, "Storage Containers and Labels for Fluid-Preserved Collections," for additional information on the care of fluid-preserved specimens.

E. Labels and Labeling

Inquire about the materials a collector used to label specimens. This will give you an indication of the preservation problems that may lie ahead. Labels contain important original information about the specimen and in some cases may be the primary documentation on the object. The information recorded on a label may include:

- species scientific name
- species common name
- collector's name
- collecting location
- habitat
- collection date
- field catalog number
- collecting institution
- park code
- catalog number
- accession number
- original fixative
- preservative

All NPS specimens should have NPS labels. See *MH-II*, Appendix H, for information on labels and labeling. Ordering information is available in NPS *Tools of the Trade*.

1. *What types of inks should I use on labels?*

Good inks for documentation are carbon printing inks, heat-fused carbon toner for printers and photocopiers, and carbon-based drafting film ink for technical pens. There are also some pigmented black inks in felt-tip pens that are acceptable for use on labels. Unfortunately, the ink often used on labels or on specimens is a dye that is acidic. It will fade when exposed to light and may fade as a result of exposure to oxygen in the air. Ballpoint pens and fugitive pencil (such as red pencils) will fade and therefore are not acceptable for writing on labels. See Williams and Hawks (1986) and Wood and Williams (1983) for information on inks and pens to use with both dry and fluid-preserved natural science collections. You can order ink and pens for labeling natural history collections through the NPS *Tools of the Trade.*

See more information on recommended inks, pens, and lettering styles and attaching strings and pins in *MH-II*, Appendix H. *COG* 11/4, “Storage Containers and Labels for Fluid-Preserved Collections,” also gives information on inks and printers.

2. *What preservation problems will I have with metal labels and tags?*

Preservation problems arise from metal ear tags, bat and bird bands, and the small metal labels that collectors used to apply catalog numbers to some fluid-preserved specimens and skeletal specimens. All these specimens may be subjected to processing or storage in fluids, at which time the labels can begin to corrode.

- Corrosion products can stain specimens and, in some instances, may cause the labels to adhere to the specimens.
- Sharp corners on the labels can tear specimens.
- Metal labels on dry skeletal material scratch and abrade the bone.
- Specimen labels made of pure tin can degrade on frozen specimens.

Though separating the labels from the specimens and storing them is one approach; it is always best to keep labels with the specimens. For bone, you can keep the labels in small polyethylene bags in the container with the specimen, but not attached directly to the bone. In fluids, you can seal the metal ear tags and leg bands in air in small glass vials with polyethylene caps and place them in the container with the specimen. These methods allow the label to remain in the container with the specimen.

3. *What kinds of paper labels are used in collections?*

Paper labels may be made of almost any paper product, many of which are not permanent or durable. The paper may be single-ply or a laminate of two or more layers. Fluid specimen labels are sometimes made of Resistall paper, a cotton rag paper that has been treated with a melamine resin to make it fluid-resistant. Resistall papers often have a fairly low pH (4.5-5.2).

Labels reduced or reproduced by photocopy processes may be alkaline buffered, acid-free paper or may be any type of common photocopy paper. The paper used in printers to generate labels falls into the same categories.

4. *What kinds of paper labels has NPS used in the past?*

Since 1982 the Museum Management Program (MMP) has specified that paper labels be of 100% white rag or alpha cellulose content or be maximum permanence paper (with alkaline filler). The MMP makes these labels available through *Tools of the Trade*. Previously, Lewis, in *Manual for Museums* (1976), specified high quality, liquid-resistant paper. Burns, in *Field Manual for Museums* (1941), recommended white linen tags tied with linen thread for mammal specimens and high quality white paper for insects on pins. Older park collections will probably contain all these types of labels in their collections, as well as other labels that outside collectors used.

You must use NPS supplied labels when tagging specimens. Specify this requirement in collecting permits. When replacing old, non-standard labels be sure to keep the originals.

Refer to *MH-II*, Appendix H, for information on natural history specimen labels and their content.

F. Glossary

*Arthropods – a*ny of numerous invertebrate organisms of the phylum Arthropoda, which includes insects, crustaceans, arachnids, and myriapods

Articulated – when parts of a skeleton are joined together for display

Biology – the science of living organisms and life processes

Bolus (boluses) – prehistoric mammoth dung

Botany – the scientific study of plants

Brachiopods – any of various marine invertebrates of the phylum Brachiopoda, having bivalve shells and a pair of tentacled, arm-like structures on either side of the mouth

Bryophyte – a plant of the major botanical division Bryophyta; includes the true mosses, peat mosses, and liverworts

Chitin – a semitransparent horny substance that forms the principal component of crustacean shells, insect exoskeletons, and the cell walls of certain fungi

Consolidation – application of a liquid polymer (glue, plastic) that imparts strength to a fragile specimen

Crustaceans – any of the various predominantly aquatic members of the taxonomic group Crustacea, characteristically having a segmented body, a chitinous exoskeleton, and paired joined limbs; includes lobsters, crabs, shrimps, and barnacles

Duff – insect excrement and shed skins left as waste on specimens; frass

Echinoderms – any of a number of radially symmetrical marine invertebrates of the phylum Echinodermata, having a body often covered with spines; includes starfish, sea urchins, and sea cucumbers

Entomology – the scientific study of animals

Exoskeleton – an external protective or supporting structure of many invertebrates

Fixing – the use of a chemical, often formaldehyde, that reacts with tissue to limit deterioration

Frass – insect excrement and shed skins left as waste on specimens; duff

Herbarium – a collection of plants mounted and labeled for use in scientific study

Holotype – the single specimen used as the basis for the original published description of a taxonomic species

Infills – a gape or hole in a specimen that is filled with a foreign material for structural stability or aesthetic integration

Invertebrate – animal lacking a backbone or spinal column

Maceration – using a liquid to soften and remove flesh

Molding and casting – techniques used by preparators and others to make copies of specimens

Mollusks – any of various members of the phylum Mollusca, largely marine invertebrates; includes edible shellfish

Nomenclature – a system of terms used in a particular science or discipline, for example, an international system of standardized New Latin names used in biology for kinds and groups of animals and plants

Ontogeny – the history of the development of an individual organism

Peel – a specimen produced by applying a polymer to the surface of an object to reproduce surface texture that is then "peeled" off

Phylogeny – the ordering of species into taxa; evolutionary history of a species

Preparation – the process of readying natural science specimens for storage in a museum collection

Scat – excrement, fecal material

Scute – plates or shells from armadillos, turtles, or tortoises

Sublimation – the conversion of a solid directly into a vapor without passing through the liquid state

Systematics – the science of classifying all organisms, living and extinct, and of investigating relationships between them; the field of science concerned with taxonomy and phylogeny

Tanning – methods used to change the chemical structure of skin making it resistant to deterioration

Taxa – plural of taxon

Taxon – a group of organisms that makes up one of the categories in taxonomic classification, such as a phylum, order, family, genus, or species

Treatment – usually refers to a repair or restoration done by a conservator

Type – a specimen or sample used as the basis of description of a species

Vertebrate – animals with segmented bony or cartilagenous spinal columns

Zoology – the biological science of animals

Sources of Glossary Definitions

The American Heritage Dictionary, Second College Edition. Boston: Houghton Mifflin Company, 1976.

Duckworth, Donald W., Hugh H. Genoways, and Carolyn L. Rose. *Preserving Natural Science Collections: Chronicle of Our Environmental Heritage.* Washington, D.C.: National Institute for the Conservation of Cultural Property, 1993.

Uvarov, E. B., and Alan Isaacs. *The Penguin Dictionary of Science*. 6th Ed. London: Penguin Books, 1986.

G. Selected References

The Nature of Natural History Collections

American Ornithologists' Union. "Report of the *ad hoc* Committee on Scientific and Educational Use of Wild Birds." *Auk*, Supplement (1975): 1A-27A.

Banks, Richard C., compiler. *Museum Studies and Wildlife Management: Selected Papers*. Washington, D.C.: Smithsonian Institution Press, 1979.

Biological Survey of Canada. *The Importance of Research Collections of Terrestrial Arthropods: A Brief Prepared by the Biological Survey of Canada*, Supplement to the Bulletin 23. Canada: Entomological Society of Canada, 1991.

Carter, David, and Annette K. Walker. *The Care and Conservation of Natural History Collections.* Oxford, UK: Butterworth-Heinemann Ltd., 1999.

Cato, Paisley. "Guidelines for Managing Bird Collections." In *Texas Tech University Museum Museology Series No. 7*. Lubbock: Texas Tech Press, 1986.

______. *Natural History Museums: Directions for Growth.* Edited by Clyde Jones. Lubbock: Texas Tech Press, 1991.

Cohen, Daniel, and Roger Cressey, eds. "Natural History Collections: Past Present and Future" In *Proceedings of the Biological Society of Washington* 82:559-762. Washington, D.C.: Biological Society of Washington, 1969.

Collins, Chris, ed. *The Care and Conservation of Palaeontological Material*. Oxford, UK: Butterworth-Heinemann Ltd., 1995.

Committee on North American Resources in Invertebrate Paleontology. *Fossil Invertebrates-Collections in North American Repositories, 1976*. Iowa City: University of Iowa and the Paleontological Society, 1977.

Committee of the Society of Vertebrate Paleontology on the Status of Fossil Vertebrate Conservation in the United States. *Fossil Vertebrates in the United States*. Society of Vertebrate Paleontology, 1972.

Conference of Directors of Systematics Collections. "The Great Collections: Their Nature, Importance, Condition, and Future." Part I. *The Systematics Biology Collections of the United States: An Essential Resource*. Washington, D.C.: National Science Foundation and the Conference of Directors of Systematics Collections, 1971.

Croat, Thomas B., compiler. "Survey of Herbarium Problems." *Taxon* 27 (1987): 203-218.

Doughty, P. S. "The State and Status of Geology in U.K. Museums," *Miscellaneous Paper No.13*. London: Geological Society and the Geology Curators' Group, 1981.

Duckworth, Donald, Hugh Genoways, and Carolyn Rose. *Preserving Natural Science Collections: Chronicle of Our Environmental Heritage*. Washington, D.C.: National Institute for the Conservation of Cultural Property, 1993.

Dunn, P. J. "The Discreditation of Mineral Species: Guidelines Endorsed by the Commission on New Minerals and Mineral Names." *Mineralogical Record* 22 (1992): 91-94.

Faber, P. L. "The Type Concept in Zoology During the First Half of the Nineteenth Century." *Journal of the History of Biology* 9 (1977): 93-119.

Frey, J. K., Terry L. Yates, D. W. Duszynski, William L. Gannon, and S. L. Gardiner. "Designation and Curatorial Management of Type Host Specimens (Symbiotypes) for New Parasite Species." *Journal of Parasitology* 78 (1992): 930-932.

Forman, Leonard, and Diane Bridson. *The Herbarium Handbook*. Kew: Royal Botanic Gardens, 1989.

Howie, Frank, ed. *The Care and Conservation of Geological Material: Minerals, Rocks, Meteorites and Lunar Fines*. Oxford, UK: Butterworth-Heinemann Ltd., 1992.

Genoways, Hugh H., Clyde Jones, and Olga L. Rossolimo, eds. *Mammal Collection Management*. Lubbock: Texas Tech Press, 1987.

Herholdt, Elizabeth, ed. "Natural History Collections: Their Management and Value." *Transvaal Museum Special Publication No. 1*. Pretoria: Transvaal Museum, 1990.

Hounsome, M. V. "Research: Natural Science Collections." In *A Manual of Curatorship: A Guide to Museum Practice*, 2d ed., edited by J. M. Thompson, pp. 536-541. Oxford: Butterworth-Heinemann, 1992.

International Commission on Zoological Nomenclature. *International Code of Zoological Nomenclature*, 3d ed. London: International Trust for Zoological Nomenclature and British Museum (Natural History), 1985.

Knutson, Lloyd, and William L. Murphy. *Systematics: Relevance, Resources, Services and Management: A Bibliography, Special Publications*. Washington, D.C.: Association of Systematics Collections, 1988.

Lee, Welton L., Bruce M. Bell, and John F. Sutton. *Guidelines for Acquisition and Management of Biological Specimens*. Lawrence, Kansas: Association of Systematics Collections, 1982.

Melville, Richard V. *Towards Stability in the Names of Animals: A History of the International Commission on Zoological Nomenclature 1895-1995*. London: International Trust for Zoological Nomenclature, on behalf of the International Commission on Zoological Nomenclature, 1995.

Miller, Edward H., ed. "Museum Collections: Their Roles and Future in Biological Research." *Occasional Papers Series No. 25*. Province of British Columbia: British Columbia Provincial Museum, 1985.

Miller, Scott E. "Biological Diversity and the Need to Nurture Systematics Collections." *American Entomologist* 37 (1991): 76.

______. "Entomological Collections in the United States and Canada: Current Status and Growing Needs." *American Entomologist* 37 (1991): 77-84.

Reynolds, Daniel, and J. Taylor. "DNA Specimens and the 'International Code of Botanical Nomenclature.'" *Taxon* 40 (1991): 311-315.

Simmons, John E. "Herpetological Collecting and Collections Management." *Herpetological Circular No. 16*. Tyler, Texas: Society for the Study of Amphibians and Reptiles, 1987.

Solem, Alan, William K. Emerson, Barry Roth, and Fred G. Thompson. "Standards for Malacological Collections." *Curator* 24 (1981): 19-28.

White, J. S. "Some Aspects of Modern Mineral Specimen Curation." *Mineralogical Record* 22 (1991): 251-254.

Wiktor, J., and R. Wladyslaw. *Bibliography of Catalogues of Type Specimens in World Zoological and Paleozoological Collections*. Wroclaw, Poland: Wroclaw University Press, 1991.

Williams, B. *Biological Collections UK*. London: Museums Associations, 1987.

Wood, R.M., and S. L. Williams. "An Evaluation of Disposable Pens for Permanent Museum Records." *Curator* 36(1993): 189-200

Zorich, Diane, and K. Elaine Hoagland. *Status, Resources, and Needs of Systematics Collections.* Washington, D.C.: Association of Systematics Collections, 1995.

Collecting and Preparation Techniques

Many of the sources cited in the section above also contain information on collecting and preparation methods.

Anderson, Rudolph M. *Methods of Collecting and Preserving Vertebrate Animals*, *National Museum of Canada Bulletin No. 69, Biological Series No. 18*. Ottawa: National Museum of Canada and the Department of the Secretary of State, 1965.

Burns, Ned J. *Field Manual for Museums*. Washington, D.C.: National Park Service, 1941.

Cannell, Peter, C. S. Asa, and M. R. Bakst. "Suggestions Regarding Alcoholic Bird Collections." *The Condor* 90 (1988): 500-503.

Cumberland, Barbara. "Using Freeze-dried Animal Specimens in Exhibits." *CRM* 22:7 (1999):23-26.

Faber, P. L. "The Development of Taxidermy and the History of Ornithology." *Isis* 68 (1982): 550-556.

Fink, William L., Karsten Hartel, Ellie Koon, William Saul, and Edward Wiley. *A Report on Current Supplies and Practices Used in Curation of Ichthyological Collections*. Washington, D.C.: *Ad hoc* Subcommittee on Curatorial Supplies and Practices of the American Society of Ichthyologists and Herpetologists Ichthyological Collection Committee, 1979.

Fitzgerald, Gerald R. "Documentation Guidelines for the Preparation and Conservation of Paleontological and Geological Specimens." *Collection Forum* 4 (1988): 38-45.

Garrett, Kimball L. "Documentation Guidelines for the Preparation of Biological Specimens." *Collection Forum* 5 (1989): 47-51.

Hangay, G., and M. Dingley. *Vertebrates.* Vol. 1. Biological Museum Methods. London: Academic Press, 1985.

______. *Plants, Invertebrates and Techniques*. Vol. 2. Biological Museum Methods. London: Academic Press, 1985.

Harris, R. H. *A Selective Bibliography on Preservation, Macro and Micro-anatomical Techniques in Zoology, Report No. 3*. United Kingdom: Biology Curators' Group, 1984.

Hawks, Catharine, and Stephen Williams. "Arsenic in Natural History Collections." *Leather Conservation News* 2: 1-4.

Hawks, Catharine, and David Von Endt. "Mercury and Mercury Compounds in Natural History Collections: An Annotated Bibliography." *Natural History Conservation* 5 (1990): 4-19.

Hildebrand, Milton. *Anatomical Preparations*. Berkeley and Los Angeles: University of California Press, 1968.

Horie, C. Velson, ed. "Peparation and post-preparation treatment of specimens in fluids." *Conservation of Natural History Specimens: Spirit Collections*. Manchester, England: The Manchester Museum and the University of Manchester, Department of Environmental Biology, 1989.

______ and R. G. Murphy. “Preparation and Post-preparation Treatments of Specimens.” *Conservation of Natural History Specimens: Vertebrates*. Manchester: The Manchester Museum and the University of Manchester, Department of Environmental Biology, 1988.

Howie, Frank M. “Materials Used for Conserving Fossil Specimens Since 1930.” In *Adhesives and Consolidants*, edited by N. Bromelle, E. Pye, P. Smith, and S. Thomson, London: International Institute for Conservation, 1984.

______. “Conserving and Mounting Fossils: A Historical Review.” *Curator* 29 (1986): 5-24.

Lewis, Ralph. *Manual for Museums.* Washingtron, D.C.: National Park Service, 1976.

McElman, James F., Kenneth Sulak, and Lou Van Guelpen. “References for the Preparation of Ichthyological Specimens.” *Curation Newsletter* 9 (1987): 7-15.

Nagorsen, David, and Randolph Peterson. *Mammal Collectors' Manual, Life Sciences Miscellaneous Publication*. Toronto: Royal Ontario Museum, 1980.

Pritchard, Mary Hanson, and Gunther Kruse, compilers. *The Collection and Preservation of Animal Parasites, The Harold W. Manter Laboratory Technical Bulletin No. 1*. Lincoln and London: University of Nebraska Press, 1982.

Rogers, Stephen P., Thomas Gutebier, and Mary Ann Schmidt, compilers. *An Annotated Bibliography on Preparation, Taxidermy, and Collection Management of Vertebrates with Emphasis on Birds, Special Publication No. 15*. Pittsburgh: The Carnegie Museum of Natural History, 1989.

Rogers, Stephen P., and D. Scott Wood, compilers. *Notes from a Workshop on Bird Specimen Preparation*, held at The Carnegie Museum of Natural History in Conjunction with the 107th Stated Meeting of the American Ornithologists' Union. Pittsburgh: The Carnegie Museum of Natural History, 1989.

Rose, Carolyn L., and Amparo R. de Torres, eds. *Storage of Natural History Collections: Ideas and Practical Solutions,* Iowa City, Iowa: Society for the Preservation of Natural History Collections, 1992.

Carolyn L. Rose, Catharine A. Hawks and Hugh H. Genoways, eds. *Storage of Natural History Collections: A Preventive Conservation Approach,* Iowa City, Iowa: Society for the Preservation of Natural History Collections, 1995.

Scott, Norman J., and Aida Luz Aquino-Shuster. “The Effects of Freezing on Formalin: Preservation of Specimens of Frogs and Snakes.” *Collection Forum* 5 (1989): 41-46.

Steedman, H. F., ed. *Zooplankton Fixation and Preservation*. Paris: The UNESCO Press, 1976.

Thomas, Robert A., compiler. “Selected Bibliography of Certain Vertebrate Techniques.” *U.S. Department of the Interior, Bureau of Land Management Technical Note No. 306*. Washington, D.C.: U. S. Government Printing Office, 1977.

Upton, Murray S. “Aqueous Gum-Chloral Slide Mounting Media: An Historical Review.” *Bulletin of Entomological Research* 83 (1993): 267-274.

Wagstaffe, Reginald. *Vertebrates, Botany, and Geology*. Vol. 2: The Preservation of Natural History Specimens. New York: Philosophical Library, 1955-1968.

______ and J. Havelock Fidler, eds. and compilers. *Invertebrates*. Vol. 1. The Preservation of Natural History Specimens. New York: Philosophical Library, 1955-1968.

Waller, Robert, and Thomas Strang. "Physical Chemical Properties of Preservative Solutions-I. Ethanol-Water Solutions." *Collection Forum* 12 (1996): 70-85.

Whybrow, Peter. "A History of Fossil Collecting and Preparation Techniques." *Curator* 28 (1985): 5-26.

Williams, Stephen, and Catharine Hawks. "Inks for Documentation in Vertebrate Research Collections." *Curator* 29 (1986): 93-108.

Wood, Rose. "A Note on 'Inks.'" *SPNHC Newsletter* 2 (1988): 1.

______ and Stephen Williams. "An Evaluation of Disposable Pens for Permanent Museum Records." *Curator* 36 (1993): 189-200.

Yasutake, William T. *Collection and Preparation of Fish Specimens for Histological Examination, Fish and Wildlife Leaflet No. 11*. Washington, D.C.: United States Department of the Interior Fish and Wildlife Service, 1987.

Health and Safety

Goldberg, L. "A History of Pest Control Measure in the Anthropology Collections, National Museum of Natural History, Smithsonian Institution." *Journal of the American Institute for Conservation 35(1996): 23-43.*

Henry, E. E. "The Merckoquant 10026 Arsenic Test for Natural History Collections." *WAAC Newsletter* 18:1 (1996).

Makos, Katherine A., and Elizabeth C. Dietrich. "Health and Environmental Safety." In *Storage of Natural History Collections: A Preventive Conservation Approach*, edited by Hugh H. Genoways, Catharine A. Hawks, and Carolyn L. Rose, pp.233-254, 1995.

Professional Newsletters and Journals

American Mineralogist
Journal of the Mineralogical Society of America
1015 18th Street NW, Suite 601
Washington, DC 20036
<http://www.minsocam.org/AmMin/ammin.html>

Association of Systematic Collections (ASC) Newsletter
1725 K Street NW, Suite 601
Washington, DC 20006-1401
Email: asc@ascoll.org.

Biology Curator's Group Newsletter
Biology Curator's Group
The National History Museum
Cromwell Road
London SW7 5BD
UK

*Circaea***,** the Bulletin of the Association for Environmental Archaeology

Professor Don Brothwell, AEA Chair	Wendy Carruthers, Newsletter Editor
Department of Archaeology	Sawmills House
University of York	Castellau
King's Manor	Pontyclun
York Y01 2EP	Llantrisant CF7 8LP
UK	UK

<http://super3.arcl.ed.ac.uk/aea>

Collection Forum
Society for the Preservation of Natural History Collections (SPNHC)
Museum of Natural History
Division of Fishes
MRC 159
Washington, DC 20560
<http://www.geo.ucalgary.ca/spnhc/>

Conservation News
United Kingdom Institute for Conservation
6 Whitehorse Mews
Westminster Bridge Road
London SE1 &QD
UK

Curator
The Museum Journal
California Academy of Sciences in partnership with AltaMira Press
AltaMira Press c/o Sage Publications
2455 Teller Road
Thousand Oaks, CA 91320
<http://www.altamirapress.com>

The Geological Curator
Geological Curator’s Group
University of Glasgow
<http://www.gla.ac.uk/Museum/John/GCG/geolcura.html>

Journal of the American Institute for Conservation
of Historic and Artistic Works
1717 K Street NW, Suite 301
Washington, DC 20006
<http://palimpsest.stanford.edu/aic/>

Journal of Evolutionary Biology
Birkhauser Verlag AG
Birkhauser Publishing Ltd.
P.O. Box 250
CH-4105 Biel-Benken
Switzerland
<http://www.birkhauser.ch/journals/3600/3600_aim.htm>

For issues published in 1999 and later:
Blackwell Science, Ltd.
Osney Mead
Oxford, OX2 OEL
UK
<http://www.blacksci.co.uk/products/journals.htm>

Journal of Mammology
American Society of Mammologists
H. Duane Smith, Secretary-Treasurer
Monte L. Bean Life Science Museum
Brigham Young University
Provo, UT 84602-0200
<http://www.wku.edu/~asm/asminfo.html>

Leather Conservation News
c/o Paul Storch, Editor
Minnesota Historical Society
Conservation Dept.
345 Kellogg Blvd. West
St. Paul, MN 55102-1906

Natural History Conservation
Newsletter of the International Council of Museums (ICOM)
Committee for Conservation
Maison de l'UNESCO
1 Rue Miollis
75732 Paris Cedex 15
France

Nature, International Weekly Journal of Science (Macmillan Publishers)
Nature America Inc. (for North, South, and Central America)
P.O. Box 5055
Brentwood, TN 37024-5055

SPNHC Newsletter
Society for the Preservation of Natural History Collections
Invertebrate Paleontology
Peabody Museum of Natural History
Yale University
170 Whitney Avenue
P.O. Box 208118
New Haven, CT 06520-8118
<http://www.spnhc.org>

Taxon,
International Association for Plant Taxonomy
c/o The Botanic Garden and Botanical Museum Berlin – Dahlen (BGBM)
Freie Universitat Berlin
Konigin-Luise-Str. 6-8
14191 Berlin
Germany
<http://www.bgbm.fu-berlin.de/IAPT/Taxon/default.htm>