Chapter 6
Conservation of Human Remains from Archaeological Contexts

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A wide range of human remains are held in the British Museum collection. These include skeletons, bog bodies, mummies, human remains preserved using other indigenous preservation techniques, spontaneous ('natural') mummies, human tissue such as hair and also fragments of bone or teeth, samples and slide preparations of human tissue. Most surviving human remains consist of skeletal and dental material alone. Mummified remains and bog bodies are less frequently encountered and include the presence of non-bony tissue, thereby offering a different range of potential information about past lives.

Human remains are recovered from a wide range of archaeological contexts. Their degree of preservation depends on several factors including the condition of the body before burial, the success of any preservation techniques, the rituals of deposition, the local climate and the burial environment. When human remains are found during an archaeological excavation or investigation, they require informed and thoughtful retrieval on site and appropriate care in subsequent storage. Additional material found associated with the human remains complements the information offered by the body itself, so any related finds should be treated with equal care and respect.

This chapter describes the condition, recovery, treatment and storage of human material from archaeological sites held in the collection of the British Museum, followed by a discussion of the care of bog bodies, intentionally mummified human remains and spontaneous mummies. The ethos of conservation is also discussed, and case studies are included to help illustrate the care of each type of human preservation. The protocols described in detail for skeletal material, such as conservation assessments and hygiene recommendations, are equally applicable to all human remains.

Conservation of human remains

Conservation has a key role to play in making human remains available and accessible for long-term study. Conservators seek to preserve the past for the future by using a variety of techniques. The aim of treatment is to extend the 'life' of an item so that the information that is intrinsic – the story of the artefact, collection or human remains – continues to be available over an extended period of time. Information relevant to conservation intervention includes the scientific, historical and cultural background. A conservator therefore needs a multifaceted understanding of any item that they are working to preserve, including the range of materials present; how all parts were made and assembled; the present condition; the types of decay and the reasons why it has occurred; the processes which have led to the continued existence of the item as well as those that may threaten its survival; current professional standards regarding treatment and environmental condition recommendations; present (and future) curatorial, study and storage needs; and the intended use and destination (loan, display, study or storage). The fundamental sense of care a conservator develops when working with objects translates easily into treating and caring for human remains, but there are additional considerations namely institutional, national (such as the *Guidance for the Care of Human Remains in Museums* issued by the Department for

Culture, Media and Sport) and international policies, legislation and guidance regarding the care of human remains (see Chapter One, this volume), in addition to the range of scientific analytical processes presently used in the interpretation of the remains, as well as an anticipation of the ones that are likely to be significant in the future.

The process of conservation in itself offers insights concerning the material under study (Coddington and Hickey 2013), and the conservator may discover information that contributes to scholarship in conservation and other disciplines. The aim therefore when working with human remains is both to preserve the body and to maximize present and future opportunities for access to information. Accredited conservators in Britain follow the European Confederation of Conservator-Restorers' Organisations 2003 code of ethics; Article 9 requires conservators to strive to ensure their methods and materials are as reversible and stable as possible. No treatment should fundamentally alter or contaminate the subject of the work, nor should it interfere with present or future analyses. In terms of treating human remains, an approach of minimum intervention is followed. This increases the potential for successful further study and analyses, both now and in the future. It also accords well with the demands and sensitivities of stakeholders such as curators, bioanthropologists, scientists, relevant communities or museum visitors.

During excavation, good procedures are essential in preparing for the recovery of human remains and subsequently in applying strategies for the treatment, packing, later housing and study. There should also be clear, accessible protocols in place before human remains are encountered so that people know what to do and who to approach if a discovery is made. For museums, appropriate protocols should be in place regarding the care, handling and study of human remains (see Chapter One, this volume). These need to be consulted prior to interacting with the human remains. Protocols include international, national and institutional human remains policies, COSHH (Control of Substances Hazardous to Health) assessments, risk assessments (see Appendix 1 for a recent example), adapted where necessary to the individual or collection to be studied, treated or displayed.

Working with human remains can be emotionally sensitive or even difficult (Balachandran 2009). This is especially true of remains that include soft tissue, hair or skin and where the remains are physically discernible and have a clear and recognizable physical presence. Treatment requires not only care, understanding and good handling skills, but also sensitivity on many levels. Even those who are well informed, carefully selected, prepared and acclimatized may become distressed by the presence of the dead. People cannot fully anticipate their own reactions to working with human remains, so special preparation for such tasks is needed in terms of risk assessments and care should continue to be shown throughout the period of work. Working with human remains can also be a fascinating journey, revealing the living aspects of the dead and making their individual stories available to others.

Human skeletal material

This discussion will begin with the most frequently encountered form of human remains from archaeological contexts: skeletons.

Preservation

Human bone includes an organic component (collagen), but mostly consists of a mineral component (hydroxyapatite), which increases the likelihood of preservation when compared with soft tissue. The state of the bones when found depends on their condition at burial and subsequent environment. An alkaline burial environment, such as a chalky soil, will result in the loss of organic component and bone becomes very brittle. An acidic environment, such as a sandy soil, will result in the loss of mineral components. In extreme situations, such as the excavations of Anglo-Saxon burials at Sutton Hoo, the very high acidity of the sandy soil (pH 3–4) resulted in the bodies decaying to such an extent that in some cases they were only present as a dark stain (Hummler and Roe 2013; Evans 2013).

Excavation and recovery

The condition and fragility of materials must be assessed before moving them from the burial context. The presence of cracks, surface crumbling or soft tissue should be assessed. This may differ from bone to bone, for example epiphyses (ends of long bones) and pathological bone (i.e. showing evidence of disease) may be particularly fragile. The bones need to be supported when lifting and any loose or broken pieces must be collected. This can usually be done by appropriate placement of hands beneath and around the bone. The bone can then be eased directly onto a flat, rigid supportive surface such as a tray or even a hand shovel with padding as appropriate. It may be advisable to leave soil in place around bones if this helps to support them during removal from their archaeological context. In some cases supportive materials can be slid underneath the bone to aid lifting; however care must be taken that there is nothing of archaeological significance directly below the bone, as it could be damaged by this approach. Usually a careful lifting technique is sufficient. In the past people have used resins and adhered unnecessary supporting materials, but these can be difficult to remove, can cause damage and also affect future analysis (Cronyn 1990, 5). Where fragile bone is present, advice should be sought from a conservator. If a conservator is not available, it is important to ensure that all pieces are individually supported with inert materials such as acid-free tissue paper or polyethylene foam (Plastazote®) during packing for removal from the site. Any material adhering to the bone also needs to be assessed early in the process of removal from the ground. Conservators and archaeologists alike should question whether such matter is dirt or something that has been deliberately applied to the bone such as red ochre. It is also important to assess how strongly such material is attached or adhering to the bone and to therefore support it where necessary to prevent loss.

Damp, but not waterlogged, robust bones should be left to dry out of direct sunlight post-excavation before any further handling or treatment is carried out. If the bone and teeth are in good condition, and there is no tissue or culturally applied materials present, the following procedure can be carried out. Bones can be gently dry brushed to remove any loose adhering soil using a soft paint brush. Soil may be retained for future scientific analysis, particularly if recovered from the stomach area (e.g. sacrum, spine or ribs). As far as possible, skeletal remains should not be washed on site. If washing is absolutely necessary, the bones should not be saturated and should be cleaned with a soft paint brush and minimal amounts of water. Bones or teeth should never be immersed in water. Soil should not be left inside skulls as it can harden and crush the bones, but equally it should only be removed if it comes out easily. If this is not the case, the skull can be packed in a supportive manner and the advice of a conservator sought. Soil should not be confused with preserved soft tissues (i.e. eyes or brain) or items such as bandages, which should not be removed but retained separately in a sealed polythene bag and packed together with the skull. The ear orifices should only be cleaned out in a controlled environment (as they contain very small ear bones that may otherwise be lost). Teeth can appear strong on the outside, but can be fragile internally. If cleaning is required this should be done very gently to ensure that calculus deposits are not removed and that the surfaces of teeth are not marked. Dry brushing should be avoided as it can damage the surface tissues (enamel) and affect future research (e.g. dental microwear studies). If required, cotton wool buds slightly dampened with deionized water can be used, gently rolled over the soiled area to pick up loose dirt. Bones from lead coffins have additional problems as health and safety personal protective equipment appropriate for lead should be worn. Lead dust should be vacuumed away with a lead appropriate vacuum cleaner. Bones should be stored in sealed packaging, labelled with lead hazard warnings.

Conservation and handling

The treatment of bones to strengthen them during and after excavation has a long history. Materials used in the past include paraffin wax, animal glue, shellac, polyvinyl acetate emulsions, acrylic emulsions and more recently acrylic resins in solvent (Shelton and Johnson 1995). These could have been applied over layers of dirt and may be shiny or discoloured, which makes it difficult to see surface detail of the bone. They can also shrink, causing damage to the bone surface. These materials can also be difficult to remove and a range of solvents may be required depending on their solubility. These solvents are usually applied to the surfaces in small amounts using cotton wool buds. Recently, tests have been carried out to remove these old resins using lasers and preliminary results are promising (Korenberg *et al.* 2012).

Past reconstructions of bones, particularly skulls, have taken place using a range of inappropriate materials such as Plasticine®, nails and cocktail sticks (Ward 2003). Often the fragile break edges have not been strengthened by consolidation before joining. Therefore the bond is only between fragile porous surfaces and is likely to come apart very easily, leaving a layer of adhesive and a skim of bone on one side of the break edge. If the join is then repeatedly re-adhered in the same manner, this will result in a build-up of layers of bone and glue, making the join unstable and inaccurate (Cook and Ward 2008).

Skeletal remains in the British Museum collection are assessed by conservators in order to determine their condition and any conservation treatment required. Treatments are agreed in consultation with curators and physical anthropologists. Human remains are covered or screened when not being worked on. The conservator assesses how fragile the bone is, whether there is flaking, surface loss, breaks, loss of physical strength or soil present. The bone also needs to be examined for any applied substances that may relate to burial practices.

Hands should be washed before and after handling bone to prevent contamination of the bone and also as a health and safety consideration. Disposable nitrile gloves can be worn if necessary, but this will restrict the ability to determine the condition of the surface through touch. Bones should be examined on a clean padded surface to cushion them. Skulls should be immobilized to prevent movement, for example by using a cut-out ring of polyethylene foam as support. If there are no applied substances or further concerns, and depending on the type of dirt present, cleaning can take place if required. A light brush or swabs dampened with small amounts of deionized water can be used for cleaning. Solvents are usually avoided as these can affect future analysis (see Eklund and Thomas 2010). Decisions about the application of resins for joining or consolidation need to be discussed as these may also affect the potential for future analyses. Treatments are kept to a minimum as conservation practices tend to lean towards supportive storage and good handling techniques. If resins (i.e. adhesives and consolidants) are applied, materials are used which have long-term stability and are reversible.

Principally, a minimalist approach to conservation is desirable. The aim is for the material to be stable with the least intervention in terms of use of chemicals, application of resins and reconstruction. Decisions on treatment are made depending on the intended purpose of the material – research, storage or display. Therefore, compromises sometimes need to be made. For example, in some cases it is not necessary to reconstruct broken skull fragments for storage purposes. For display however, it may be appropriate for skull fragments to be joined and some missing areas filled. This should make the material more suitable, recognizable or understandable in an exhibition.

If joins are required, the porous adjoining bone surfaces require consolidation, otherwise the edges will be softer than the join itself and eventually the join will fail and pull away the surrounding bone. Bones can be held in position while adhesive is drying using various techniques, for example support in sand trays, using a separator of tissue or cling film between the bone and the surrounding material. Masking tape can also be used to hold fragments in position. However, this treatment should only be carried out on robust surfaces and used on a very temporary basis and removed within a few hours or days of application. Fills may be needed to provide support in situations where there are losses in the bones. A range of stable conservation filling materials with different properties is available for use. Very fragile bone may need to be consolidated prior to making adjacent fills and unconsolidated pieces may be kept for analysis.

Case study: Conservation practices required for the display of human skeletal remains from the Wendorf Collection

Plate 2 Cut marks on right femur of skeleton 21

Plate 3 Embedded lithic on pelvic bone of skeleton 21 observed under magnification (x6)

This case study will discuss the late Palaeolithic human skeletal remains from the Wendorf Collection in the British Museum that were conserved for permanent display. Conservation consisted of reversing a previous reconstruction of the skull, which was unsuitable for exhibition, and making new repairs to preserve its integrity and improve visual appreciation. Treatment was based on current conservation approaches following the protocols described in the British Museum Policy on Human Remains (Trustees of the British Museum 2013) and the *British Museum Guidance for the Care, Study and Display of Human Remains* (British Museum n.d.). The whole process encompassed technical complexity due to the fragile condition of the bones; however, the outcome of conservation was satisfactory both in terms of stability and legibility. It also facilitated the possible re-study of human remains as the new treatment revealed original surface and features previously obscured by extraneous additions such as old fill materials.

Collection history

In 2001 Professor Fred Wendorf, from the Department of Anthropology at Southern Methodist University in Dallas, Texas, donated to the Department of Ancient Egypt and Sudan at the British Museum a collection of artefacts, human skeletal remains and documentary material recovered and produced in the 1960s during his research projects and excavations in the Nubian region of Egypt and Sudan. A large proportion of this collection composed of human skeletal remains recovered from site 117 at the Palaeolithic cemetery in Jebel Sahaba, dating from around 12000 BC (Wendorf 1968, 954). They consisted of 61 individuals, some of which had embedded fragments of flint projectile points and distinct cut marks on bones that were inflicted at the time of death or shortly after (Anderson 1968, 1028). This evidence represents one of the earliest archaeological records of possible organized violence, and manifests the great potential for research of this unique collection.

The osteological material was studied in the 1960s in the laboratory of the Anthropology Research Center at Southern Methodist University in Dallas and involved some reconstruction of bones and infilling of areas of loss to record osteometric and morphological measures, principally on the skulls. The treatment resulted in significant reconstructions, which hampered the observation of some features and the restudy of the skeletal remains. When the collection was donated to the British Museum in 2001, the human remains were inventoried and assessed by bioarchaeologists and conservators (Judd 2002; 2003; Wills and Ward 2002; Ward 2003). Bones were bagged and packed appropriately to ensure a safe storage that could guarantee their long-term preservation, and some of the skeletons that required further conservation treatments were flagged. Two of these skeletons were selected for display in the then recently refurbished Early Egypt gallery at the British Museum, The Raymond

Plate 1 Skeleton 21 in the burial context at Jebel Sahaba, *c.* 12000 BC. British Museum, London (EA 77841)

Plate 4 Ulna bone of skeleton 21 showing oversized numbers

Plate 5 Cranium and mandible of skeleton 21 before conservation

and Beverly Sackler Gallery (Room 64). The human remains discussed here are of skeleton 21 (EA 77841) (**Pl. 1**) belonging to a robust middle-aged adult male. The skeleton presented evidence of trauma with distinct short and deep cuts in long bones and clavicles (**Pl. 2**), and some embedded fragments of lithics in the pelvic bones (**Pl. 3**). The skull was extensively reconstructed and needed to undergo conservation treatment before display.

Condition of human skeletal remains before conservation

The skeleton was fragmentary, with only around 40% of the bones present, while the skull was almost complete, with approximately 90% of the bone preserved (Judd 2003). After excavation, most of the bones from the skeleton were labelled with oversized numbers using a thick, waxy, black paint that had penetrated through the porous surface producing irreversible markings (**Pl. 4**).

The bones were dusty with mixed soil and sand from excavation. They showed patchy white accretions, some loose and powdery, others hard and well attached to the bone surface. Both types were identified as anhydrite ($CaSO_4$), formed as a result of the recrystallization of the sulphate and the calcium from the soil absorbed by the bone (Robinet 2002). Nonetheless, these accretions appeared to be stable and were not damaging the original surface.

Most of the bones of the skeleton were fragmented and showed inappropriate repairs, carried out without previous cleaning of the broken edges. The repairs exhibited soil deposits from the excavation mixed with thick coatings of a rubbery white adhesive identified as polyvinyl acetate (PVA) (Robinet 2002). As a result of this, some of the repairs had failed and others were loose and at risk of breaking. A close examination revealed that the reconstruction of the skull was not completely accurate. There were slight misalignments on joins and some of the infilled areas had been over-interpreted to simulate completeness (**Pl. 5**).

In some cases, integrations were poorly applied and covered the original surface of the bone, which contributed to the unusual morphological appearance of the skull. In addition to this, the materials used as fillers were not of conservation quality. Missing parts of the palatal, nasal and frontal bones had been infilled with a grey modelling material similar to Plasticine composed of kaolinite clay. The infills were surface-coated with a thick layer of PVA adhesive to increase strength, and some of them were supported on a structure formed of wooden cocktail sticks fixed to the bone with a generous application of the same PVA adhesive (Robinet 2002) (**Pl. 6**). The skull and mandible were covered with a shiny resin similar to cellulose nitrate which was soluble in acetone (Robinet 2002). The resin had discoloured and appeared yellow. The dentition on the skull was vulnerable. Some teeth were loose or, unfortunately, adhered to the maxilla and mandible. Some small fragments of the teeth had not been repositioned and were kept apart inside a small plastic bag.

Rationale for treatment

The skeletal remains could not be displayed in this condition. The bones needed to be stabilized and their appearance improved for display. The skull, which presented a more invasive treatment, was prioritized for conservation together with those bones presenting evidence of cut marks or possible embedded lithics. Considering the fragility of the skeletal remains, the skull in particular, it was initially thought that the previous reconstruction could be maintained by bringing down the shine of the adhesive coating and improving the surface of the infills. This would have minimized any possible damage occurred during re-treatment and significantly reduced the amount of time required for conservation.

Plate 6 Former reconstruction of the palatal bone of skeleton 21 using wooden picks and Plasticine during dismantling

Plate 7 Removing Plasticine filler from skeleton 21

However, after careful examination of the assemblage and an analysis of materials, it was believed that the complete removal of the previous treatment would considerably improve the appearance of the skull. More importantly, this would help to present its morphology in a more accurate way by removing obtrusive fillers, wooden cocktail sticks and Plasticine. Likewise, the removal of oversized excavation numbers would help to avoid the possible perception of human remains on display as mere 'objects'. The level of conservation and quality of the previous treatment was discussed in liaison with the Curator of Physical Anthropology and other conservators specialized in the treatment of human remains. It was finally agreed that conservation had to be based on the principle of minimum intervention regarding the extent of infilling and consolidation, whereas repairs needed to have a certain aesthetic quality in order to not be obtrusive.

Conservation treatment for display

Although the previous reconstruction had been rather invasive and had covered the original surface of the bone, the new treatment tried not to jeopardize residual evidence that could be the subject of future investigations or analysis. Principally, conservation work consisted of the surface cleaning of bones, the removal of aged adhesives, fillers and coatings, the stabilization of friable areas compromised by repairs and the reassembling of the skull. It was a labour-intensive treatment that required careful manipulation and thoughtful planning. Surface cleaning was kept to a minimum. The bones of the skeleton were gently brushed to remove loose deposits of soil and accretions, while hard, calcified accretions were not treated as they seemed stable. Although no new information was revealed, cut marks on bones and embedded lithics were more noticeable after cleaning. Previous joins were undone when they exhibited excess of adhesive, were failing or inappropriate. The adhesive was softened with cotton wool pads of acetone covered with aluminium foil to reduce evaporation. After the removal of aged adhesive, the broken surface was consolidated with Paraloid B72® (ethyl methacrylate, acryl methacrylate copolymer) applied with a fine brush at 5% w/v (weight/volume) in acetone. At this point, the bones were reassembled with the same resin prepared at 20% w/v in acetone.

New conjoins of bones presenting fresh breaks were made with the sole purpose of improving the recognizability of the skeletal elements on display. This was partly successful in the case of the pelvic bones, which were rather fragmented and could be reassembled into larger pieces. The process was carried out with particular care not to compromise possible evidence of trauma. As a general rule, the use of consolidants and adhesives was localized and applied only when strictly necessary. Although these had already been extensively used in the previous treatment, there was a concern that they could compromise future investigations such as DNA analysis or radiocarbon dating (D'Elia *et al.* 2007; Eklund and Thomas 2010; Johnson 1994).

Numbers on bones were mechanically removed under an optical microscope using a scalpel blade to eliminate only superficial layers of the paint. Further cleaning was attempted with cotton wool swabs slightly moistened in acetone. However, part of the paint was anchored to the porous surface of the bone and it was not possible to remove it completely. Nonetheless the result of cleaning was satisfactory as the numbers are now only visible at very close sight. The resin coating on the skull was unsightly and unnecessary and was carefully reduced using acetone applied with cotton wool swabs. The original surface revealed was significantly improved and no additional consolidation was required. Old filler was mechanically removed with a fine scalpel and the application of cotton wool pads of acetone was used to soften the adhesive coating. Sharpened wooden skewers were also used to reveal fragile bone surface along the edges of the infilled areas (**Pl. 7**).

After removal, some of the joins had insufficient or unstable contact surfaces that required additional support for reconstruction. This was the case of the left zygomatic suture, which was reinforced with Paraloid B72 applied at 40% w/v in acetone mixed with glass microballoons. As previously, the areas to be infilled were consolidated with Paraloid B72 at 5% w/v in acetone in order to protect and strengthen the fragile bone surface before the filler was applied. The material used to fill the areas of loss had to be lightweight, but relatively hard and strong to compensate for

Plate 8 Skull of skeleton 21 showing infills before inpainting

Plate 9 Skull after treatment, front and left sides

the weak structure of the skull. Materials like plaster of Paris and Paraloid B72 bulked with glass microballoons were initially considered for gap-filling; however, they were thought to be excessively hard in comparison to fragile bones, or difficult to apply, which posed a serious problem in areas with limited accessibility. A mock-up infill was made using Flügger® putty. Flügger is a fine paste composed of butyl methacrylate and calcium carbonate. It is a ready made material, and can be easily applied with a spatula. The test showed that some shrinkage occurred after drying; however, the putty could be reapplied as many times as necessary to correct any imperfection. It was therefore decided that this product should be used for gap-filling.

Applied on the bone, the putty provided optimum structural strength and hardness (**Pl. 8**). The final surface was rather smooth and needed minimum improvement after application; a simple rubbing of the surface with a cotton swab moistened in acetone was sufficient to achieve a smooth finishing for colouring. Liquitex® acrylic paints and Schmincke® gouache colours were tested for inpainting and eventually the mixture of both products delivered the best colour effect. The acrylics produced a solid covering film; however, this resulted in a plastic and shiny appearance that could only be reduced in combination with the gouache paints (**Pl. 9**). The colour was applied with a fine brush and toned in with the original surrounding areas using a uniform and neutral colour that made the infills unobtrusive, but clearly distinguishable.

Packing and padding the storage box

Once cleaned and repaired, the bones were repacked inside a lidded rigid cardboard box. Bones were put inside polyethylene zip-lock bags with some folded acid-free tissue paper to prevent further fractures or excessive movement during transport. When possible, bones were bagged individually and the original paper labels were kept with them. As an additional labelling system, bags were marked using small circular stickers to indicate the possible presence of cut marks (green stickers) or embedded lithics (red stickers). A card with a legend was introduced inside the storage box so users could understand the colour code.

The disposition of the bones inside the box was carried out according to the guidelines proposed by the Museum (see Chapter Five, this volume) and taking into consideration the condition of bones. The more robust and larger bones were placed at the bottom, such as bones from the legs and arms. The bones from the pelvis were also placed at the lower level. As they are very fragile they were stored in special clear polystyrene boxes, padded with a Plastazote base and spider tissue (100% mulberry fibres), which created a soft and smooth pillow around them. Smaller bones corresponding to the hands, feet, vertebrae and scapulae were carefully placed on top of them trying to create uniform layers. The skull and mandible were placed at the top of the box together with fragile bones exhibiting various repairs (**Pl. 10**).

These bones were supported on a piece of Plastazote and secured to it with bowknots of cotton tape, in order to prevent movement and the possibility of new breaks occurring during transport or handling (**Pl. 11**). The skull was safely supported during treatment on a circular cushion in the shape of a 'doughnut ring' made out of cotton calico fabric padded inside with polyester wadding. During treatment the cushion was covered with clear plastic wrap (cling film) to avoid soiling, but this was removed and the cushion reused as a handling and storage support (**Pl. 12**).

Plate 10 Bones inside the storage box after treatment

Plate 11 Storage foam support for fragile fibula with various repairs

Plate 12 'Doughnut ring' to support the skull in storage or during handling

Conclusions

The new treatment of the human skeletal remains using conservation grade materials ensured their long-term preservation and minimized the need for further intervention in the future. Bones were stabilized successfully and the new repairs and infills helped to strengthen fragile joins and weak areas. The new repairs were sympathetic with the nature of bone and well integrated with the original surfaces, reducing considerably the visual disruption caused by the areas of loss. The treatment reached a good balance between minimal interventive conservation and a more aesthetic approach in order to prepare the human remains for display. The large fragmentation and loss of skeletal remains required an interventive approach to improve the morphological appearance of the bones. It is expected that further conservation work will be carried out on the rest of the skeletons from the Wendorf Collection; however, treatments will follow a remedial approach aimed only at facilitating access and research.

Human remains with preserved soft tissue

The best examples of extensively preserved human remains come from extreme contexts such as wet, arid or frozen environments that inhibit the deterioration of soft tissue. As discussed below, ancient waterlogged bodies from northern European bogs, such as Lindow Man (see Chapter Two, this volume) tend to have exceptional soft tissue preservation although less skeletal survival. Similarly, consistently dry areas such as Egypt, Sudan and the high areas of the Andes can provide examples of exceptionally good soft tissue preservation (an example is a child mummy from Chile in the British Museum; **Pl. 13**), and bodies that are frozen soon after death also survive remarkably well in that state. Perhaps the best known example of this kind is 'Ötzi the Iceman' who lived around 3300 BC (on display at the South Tyrol Museum of Archaeology in Bolzano, Italy). Other bodies or parts have been preserved using a range of indigenous techniques and subsequently entered museum collections (for example, shrunken heads from South America), but are not described here as these are not from an excavated context.

Bog bodies

Preservation

Several examples of well-preserved human remains have been recovered from areas of waterlogged ground such as peat bogs, usually during peat cutting. The environment in a peat bog is anaerobic and decomposition is much reduced (see Chapter Two, this volume). The high pH also contributes to the preservation of the soft tissue, but dissolves the mineral content of the bone, leaving a very fragile bone structure. The humic acids in the bog create a natural tanning of the skin which aids preservation (Painter 1991; Joy 2009; see also Chapter Two, this volume).

Plate 13 Child mummy from Chile. British Museum, London (Am1832,1208.1)

Excavation and recovery

The ideal scenario is for minimal excavation on site. The body is best lifted together with soil around it for support and to help maintain the acidity of the surrounding environment. Additional support may be required to prevent flexing, for example a wooden box padded with expanded polyurethane foam. The surrounding deposits may provide further archaeological and environmental evidence relating to the context of deposition. Once lifted, the body should be stored in the dark and kept cool to prevent biological activity. X-rays and CT scans can be used to determine the condition of the bones and internal organs. Excavation should be carried out in controlled conditions by curators, conservators and physical anthropologists, working in collaboration with one another. The body should be kept cool and wet throughout this process to prevent drying out, shrinkage and cracking (Omar *et al.* 1989).

The now well-known bog-body Lindow Man (see also Chapter Two, this volume) was lifted resting on a peat block, supported by water-soaked plastic foam and thin plastic sheeting. The block was then placed in a specially constructed box. From the time of initial excavation, the body was kept cool by storage at approximately 4°C, initially in a mortuary fridge and then in a specially constructed cooler at the British Museum. He was monitored during storage and kept wet with cooled, sterilized distilled water.

Conservation and handling

Various treatments have been used to conserve bog bodies (see Asingh and Lynnerup 2007; Omar *et al.* 1989; Chapter Two, this volume), however freeze drying is currently regarded as the standard approach. When recovered from the bog, water fills the deteriorated human tissue and so acts as a support. If left to dry out naturally, shrinkage will occur due to the high surface tension of the receding water which results in drying stresses. In the freeze drying process, the water is removed by sublimation (the water goes directly from a frozen to a vapour phase) and so drying stresses are reduced. The water is first replaced with a solution of water and a water soluble wax, usually polyethylene glycol (PEG). The body is then frozen and placed in a freeze-drying chamber. PEG is a cryoprotectant and so helps to counteract any dimensional changes due to freezing. It also helps to bulk and support the human tissue on a cellular level. This treatment was used on Meenybradden Woman (National Museum of Ireland, Dublin), Lindow Man (British Museum) and, more recently, two excavated Irish bog bodies from Old Croghan (Co. Offaly) and Clonycavan (Co. Meath), now displayed at the National Museum of Ireland (R. Reade pers. comm.). Reassessments of such treatments have been carried out over the years and, overall, they appear to have been successful (Bradley *et al.* 2009).

During the excavation of Lindow Man, various samples of tissue were taken for further analysis. Most of these are now stored in glass vials in sealed polypropylene containers mainly in distilled water (Hacke and Stacey 2008) in a fridge at 4°C and regularly monitored. Recently there has been discussion as to whether to replace the distilled water with 70% ethanol/30% distilled water as recommended for storage of this type of material by English Heritage (English Heritage 2008), but since storage in solvent can affect future DNA analysis, it has been decided to maintain current conditions. Some additional fragments of bog body were excavated from Lindow Moss several years later. At the time it was considered that this material was more valuable if stored for future analysis rather than conserved. Therefore the fragments were individually supported, packed and heat sealed within polyethylene bags, and then placed in a freezer. One small fragment was frozen in nitrogen.

Mummified human remains

Mummies from ancient Egypt

Intentionally preserved mummies from ancient Egypt have survived in remarkable condition due to the expertise of the practitioners' mummification techniques and the favourable, consistently dry burial conditions. As recovery of soft tissue is rare, and when found generally fragile, additional care and preparation is required before moving mummified human remains. Good lifting techniques may be crucial to the survival of the mummified tissue and associated materials such as linen textiles. As with bog bodies (above), the ideal scenario is for minimal intervention on site and the mummy is best lifted en bloc together with any surrounding deposits if present. Such deposits can be used to provide support and may be a source of further archaeological evidence relating to the burial. Additional support, such as an appropriate wooden box lined with temporary padding such as expanded polyethylene foam may be required to prevent flexing. All recently excavated Egyptian archaeological material, including mummies, now stays in Egypt so good communication with Egyptian colleagues and conservators is valuable and mutually beneficial.

Conservation and handling

Ancient Egyptian mummies have been part of museum collections for over a century and some have been exposed to interventions and repairs using materials and techniques that were prevalent at the time. These methods of restoration may have occurred before acquisition in order to enhance sale values. Typical materials used at the end of the 19th and the beginning of the 20th century include plaster of Paris, wooden dowels, animal glue, nails and screws, contemporary paint and textiles. Mummies were unwrapped for both study and entertainment in the West. The surgeon and antiquarian Thomas Pettigrew relished unwrapping mummies before a Victorian audience; however the Trustees of the British Museum refused to allow Pettigrew to unwrap any of the mummies in the British Museum collection as this would 'destroy the integrity of the collection' (Andrews 2004, 13).

At the British Museum, most of the mummies in the collection are still in their wrappings. As these are made from a variety of materials, any conservation treatment or other intervention is designed to take account of the associated materials, structures (such as coffins) and objects with equal consideration (Wills forthcoming). More subtle and evanescent traces may also survive (such as poured libations, flowers laid on the body or residues of mortuary

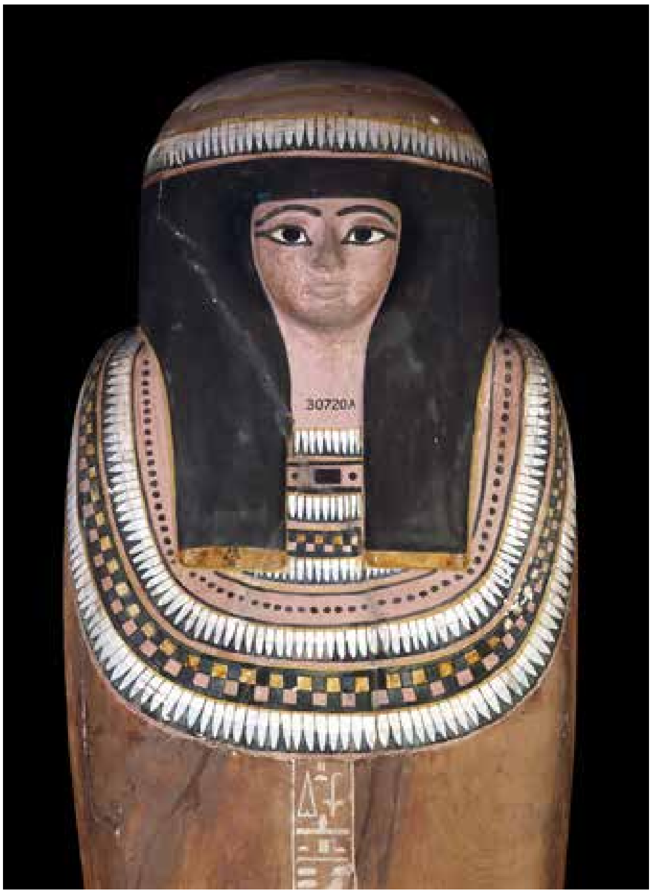
Plate 14 Preparing the mummy of Nesperennub (22nd Dynasty) for display at the British Museum (EA 30720)

practice). This wide range of preserved materials, in addition to the human remains, requires care and a good understanding of the burial practices to conserve and curate.

Conservation treatments of mummies at the British Museum developed significantly over the latter part of the 20th century. In the past, treatments were more interventive, for example adding stable conservation materials to the fragile original material in order to strengthen it. The recent tendency has been to use the minimal amount of conservation materials required with a focus on more precise, developed and technically adept interventions. Mummies chosen for long-term loan have to be both robust and stable. Mummies stabilized for storage within the collection may benefit from more subtle conservation treatment. The mummies presently on display in the Roxie Walker Galleries, Rooms 62–3, have for example been prepared by conservation for display, but not for loan.

In 2004–5, the British Museum developed an exhibition entitled *Mummy: The Inside Story* which focused on the mummy of Nesperennub, a priest of Khoms at the temple of Karnak during the 22nd Dynasty, *c.* 800 BC (**Pl. 14**). One of

Plate 15 Nesperennub: interior of the wood coffin (left) and the upper and underside of the cartonnage coffin (right)



the remarkable features of this exhibition was that the mummy could be virtually unwrapped using 3D technology. Non-invasive X-ray and computerized tomography (CT) scanning techniques made it possible to look inside the mummy without disturbing the wrappings.

The conservation treatment of Nesperennub illustrates the variety of materials and objects that can constitute a burial ensemble, which in this case consists of a wood outer coffin enclosing a cartonnage inner coffin which itself encloses the mummified body (**Pl. 15**). Close examination of the painted outer wooden coffin revealed extensive restoration (**Pl. 16**). Filler in the splits of the old wood and modern paint could be seen, confirmed by examination under ultra-violet light, which showed the modern materials clearly fluorescing (**Pl. 17**). Both filler and paint had been crudely applied over the original painted surfaces and this may have been done prior to the mummy entering the collection at the end of the 19th century. After discussion with the curator John Taylor, it was decided that only the non-original brown paint from the main body of the coffin should be removed and fills were retouched in a more visually sympathetic way.

The cartonnage was slightly dirty, the edges friable and there were areas of lifting, delaminating paint. On the foot plate, the linen ties were loose and frayed, making the foot plate liable to detach during handling. The tabs on the leather *stola* (straps placed around the neck of the wrapped mummy) were dirty, distorted and curling, with a sticky surface. One tab had a pinkish addition stitched to the upper end which was found to be attached using a modern rayon thread. After consultation with the curator, the

Plate 16 Nesperennub: detail of lid of wooden coffin before treatment (left) and detail of filler and overpaint (right)

non-original parts were removed. The tabs were cleaned to remove the sticky, dirty surface and reshaped to recover something closer to the original shape. The cartonnage was cleaned, the paint surface secured and the linen ties strengthened.

Support of the cartonnage was necessary so a mount was made from a 10mm Perspex® sheet, modified to fit the shape of the underside. The mummy case was removed from the old wood support board by gently inserting a sheet of Melinex® (clear polyester film) beneath the cartonnage, then sliding it carefully onto the new Perspex mount. The underside of the cartonnage was visible for the first time and photographs could be taken, completing the documentation of the mummy.

Spontaneous mummies

Preservation

Spontaneous mummies are created through a set of specific circumstances, none of which appear to have been deliberately chosen to produce a mummy. Contributory factors towards the spontaneous preservation of soft tissue and organic materials include the absence of a coffin which allows free air movement around the body and the presence of dry or intensely hot air. Spontaneously

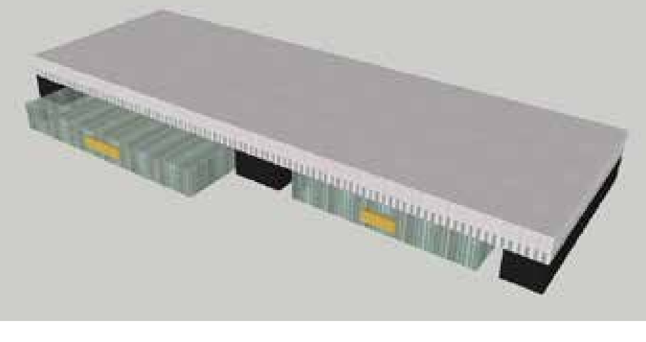
Plate 17 Nesperennub: fluorescence under ultra-violet light. More modern paints and varnish show fluorescence under ultra-violet light

Plate 18 Gebelein Man, late Predynastic, *c.* 3500 BC. British Museum, London (EA 32751)

mummified bodies can show a range of preservation states, from very good – where most of the body remains intact, complete with skin and hair – to partial, where only some of the soft tissue remains. The skeleton, however, usually remains in excellent condition when other tissues have been lost.

The British Museum has in its collection a range of spontaneous mummies originating from the Nile valley. Preservation has been inadvertently achieved primarily through the absence of moisture in the burial context, inhibiting the processes of autolysis (the self-destruction of tissues within the living body) and the decaying action of microorganisms. Examples of this type of mummy include the Predynastic mummies from Gebelein, Upper Egypt (**Pl. 18**), comprising a group of six bodies found in sand. During the Predynastic period (4400–3100 BC), the dead were buried in shallow graves cut into the desert sand, often lined with reed mats. The heat and aridity have preserved the bodies. The collection also includes a number of spontaneous medieval mummies recovered from the area of the Fourth Nile Cataract (Sudan) that have been lifted during salvage excavations (1999–2007) in advance of flooding caused by the Merowe/Hamadab hydroelectric dam (see also Chapter Three, this volume). They were given to the Sudan Archaeological Research Society by the National Corporation for Antiquities and Museums of Sudan, Khartoum, who then donated them to the British Museum (see Chapter Three, this volume). The human remains date from the 6th to 15th centuries AD. Some were interred in grave cuts of dry soil consisting of mixed alluvium and coarse sand. Lintels made of stone or mud brick may have protected, or partially protected, the body from any destructive action of soil above. However, earth-filled grave cuts also produced mummified bodies (Welsby 2003). The absence of a coffin, the aridity and the salinity of the soil all presumably contributed to the remarkable preservation of the soft tissues as well as a wide range of original wrappings comprising mostly a range of textiles, but also including skin products such as leather (Wills 2013). These 40 natural mummies from the Nile valley have been the subject of a two-year project supported by the Clothworkers' Foundation (*Safeguarding a Body of Evidence: Researching and Conserving a Group of Exceptional Naturally-mummified Nilotic Human Remains)* to clean, stabilize, support and investigate the remains, together with the associated wrappings.

Plate 19 Diagram of mount board



Stabilization and mounting

The mounting and storage system for the 40 natural mummies was designed to support the varied shapes and materials of these fragile specimens in order to keep them stable under conventional storage conditions and during study. The system, recently developed from earlier mounting techniques, is applicable not only to these human remains, but also to a wider range of fragile material. The storage area refurbishment was planned in detail, first surveying the condition of the bodies, then evaluating requirements and calculating space, materials and costs as well as the availability of practical assistance. For each individual body or related group, a stable baseboard was provided from Cellite® 220 aluminium honeycomb panel. All panel surfaces were cleaned thoroughly and rough edges smoothed, then covered with a stable tape such as adhesive-gummed linen tape. Lengths of black Plastazote were stuck beneath the baseboard, two or three according to need. These battens allow the board to be raised from the surface beneath, absorb vibration and provide space for trays (**Pl. 19**). In this instance, Plastazote density LD45 was chosen because of its resilience and ability to absorb vibration. A sheet of Plastazote 3cm thick (the softer LD33) was then cut to fit the baseboard and wrapped with Tyvek® sheeting (spunbonded olefin fibre) with the rough side on the interior. The Tyvek-wrapped 'mattress' was secured to the baseboard using a hot-melt glue. Each specimen, having been

Plate 20 Tissues secured in place with PTFE tape

Plate 21 Foot supported by padding and hammock

Plate 22 Skeleton 4310 after treatment showing body parts secured on the baseboard with other skeletal elements located in a tray that slides beneath the support board

unpacked, cleaned for study and sampled as necessary, was laid on the wrapped 'mattress' in the most appropriate way following advice from Daniel Antoine, the Curator of Physical Anthropology. Working from the centre outwards, the fragile human remains were stabilized in position by creating side and base supports using wedges of Plastazote. Where necessary to support areas of great fragility, the Plastazote was covered with polyester wadding to provide cushioning, then wrapped with Relic-wrap PTFE™ (a thin, very smooth and stable polytetrafluoroethylene film). Vulnerable detaching tissues were held in place by wrapping with PTFE tape (**Pl. 20**). The locations of the side and base supports were chosen with care to be in contact with the most stable areas of the body. Having estimated the minimum number of supports required, positioning and height, each was shaped to match the adjacent area of the body as closely as possible. A 'hammock' made of Relic-wrap created the softest of supports for the most vulnerable tissue (**Pl. 21**).

The Plastazote supports were held in place by pinning stable stainless steel pins ('Austerlitz' pins) through the support into the Tyvek-covered Plastazote 'mattress' below (**Pl. 22**). This flexible system of movable supports and pads facilitated the positioning of optimal support, and could easily be repositioned later if required. Correx® (twin wall polypropylene sheet) or Tycore® (three-layered archival quality support board) boxes were made to store samples and loose material (**Pl. 22**). These were designed to be slid beneath the baseboard to give additional support and retain the unity of the complete specimen. Finally, all mounted bodies were clearly labelled. All stages of treatment were recorded in report documentation and photographs.

This system of passive conservation using no chemicals, consolidants or adhesives was developed to avoid compromising not only present analytical procedures, but also the potential for future investigation. This method makes each part of the body as accessible as it can be while keeping it stable and secure.

Case study: Rehousing a mummified hand from the Stein Collection

Introduction

This case study will discuss preventive conservation measures to upgrade storage conditions of a mummified hand (British Museum, 1928,1022.121) and an associated wooden cylinder. The project focused on providing a supportive mount and protective box that could guarantee safe long-term storage and would avoid unnecessary handling or exposure. The hand was collected by Sir Marc Aurel Stein, who carried out three expeditions to the western regions of China between 1900 and 1916 in order to conduct archaeological excavations, geographical survey, ethnographic survey and photography. The material dates to the 7th century AD and was found during Stein's third Central Asian Expedition (1913–16) (Stein 1928, 683) in tomb-group I in the Astana cemetery, Xinjiang Uyghur Autonomous Region, north-west China, which is on the north-eastern Silk Route. The cemetery was used from the 4th to 8th century AD and contains in excess of 1,000 tombs. Due to the arid environment, the formation of spontaneous mummified human remains occurred and organic preservation was excellent.

Condition before treatment

Rehousing of the hand was requested after a survey of the Stein Collection in the British Museum's Department of Asia revealed that the existing storage conditions of the mummified hand were unsuitable. The hand seemed fragile, but relatively well preserved. The cohesion of skeletal tissues appeared to be weak and some of the carpal bones (lower hand/wrist) had detached. Despite this, the hand was almost complete and only exhibited a damaged area across the palm. The area had lost part of the soft tissues and was depressed, perhaps as a result of the weight of the associated wooden cylinder that once rested on it. This made the fragile condition of the hand even more vulnerable and considerably limited the possibility of manipulation or access to the back. The wooden cylinder was soiled, but in relatively good condition. In contrast, an original silk fabric, which was formerly wrapped around the cylinder, had disintegrated and only minute fragments were still resting on the palm of the hand (**Pl. 23**).

Plate 23 Hand and wooden cylinder before conservation, 7th century AD. British Museum, London (1928,1022.121)

Rationale for treatment

The storage solution had to protect the hand and the associated materials from dust and light. Additionally, a safe storage support was required to ensure the long-term preservation of the hand and its integrity, while minimizing the need for handling or the possibility of movement. It was noticed that the wooden cylinder accompanying the hand could be a *vajra*, a Buddhist ritual object representing strong spiritual power. Taking this into consideration, it was initially proposed to relocate the cylinder back into the hand, simulating the original position during burial. This could have been achieved by means of an additional support which would have avoided direct contact with the fragile tissues of the hand and be understood as an expression of respect, intended to return not only the physical position of the *vajra*, but also its spiritual dimension and symbolism (see McGowan and LaRoche 1996; Jones and Harris 1998).

The new storage conditions for the hand and related objects

As with most human material, the hand has potential for future research. Therefore, no interventive treatment such as cleaning or consolidation was carried out. The only action undertaken apart from providing support and protection to the assemblage was the selection and

Plate 24 Hand and wooden cylinder with associated tissues and materials prepared for storage

Plate 25 Hand, wooden cylinder and associated materials inside the new storage box

classification of decontextualized materials. Fibres, fragments of textiles and other tissues that could not be repositioned in their original context were classified and put inside small, labelled clear boxes (polystyrene). Loose soil from the burial was double-bagged inside zip-lock polyethylene bags (**Pl. 24**).

Although the idea of reproducing the original position of the wooden cylinder in the hand was received with interest, the device needed to hold the wooden cylinder would have required specialized mounting assistance, not available at the time of treatment. Therefore, the hand and the cylinder had to be mounted on separate supports that were kept inside the same storage box.

The supports were a modified form of fabric-covered museum boards, a storage system commonly used for mounting flat textiles. They were constructed from expanded polyethylene foam bases (Plastazote), lined with a thick layer of cotton domette (100% cotton fabric) to provide some padding, and finally covered with Tyvek. The Tyvek was first secured with double-sided tape adhesive to the back of the foam and then stitched to another layer of Tyvek which covered the back of the base completely. Initially, fine Bondina®, PTFE sheet and fine cotton lawn were tested as fabric covers. Bondina and PTFE sheet were too slick, while the nap of cotton lawn rendered it unsuitable in contact with the friable soft tissues of the hand. The Tyvek provided a smooth and non-slip surface that helped to hold the hand and the wooden cylinder in place. The hand was additionally supported at weak areas by means of small blocks of Plastazote lined with Tyvek and stitched to the main support (**Pl. 25**). For the wooden cylinder, two pieces of Plastazote were placed along both sides of the base to prevent the object from rolling. The cylinder was fastened to the mount with two ties made of fine silk tape (100% silk). This provided a very smooth surface and its high translucency allowed for visibility of the object (**Pl. 25**). A lidded box made of acid-free archival cardboard was made to contain the supports and the small boxes with the rest of the materials and tissues (**Pl. 25**). Old packing materials were kept in a separate box in case they could serve as reference or provide any evidence for future research.

Environmental recommendations and storage facilities

The environment in the storage room of the Stein Collection had previously been evaluated by preventive conservators (Brierly 2011). The assessment found that the environment was suitable for organic collections; nevertheless, a regular inspection was advised to detect any possible sign of further deterioration. An ambient temperature of 16–25°C and a relative humidity of 35–45% were recommended to maintain a stable condition of the human remains (see below). As a preventive measure, it was suggested to place the storage box containing the hand in a drawer of the cupboard that receives minimal disturbance, together with other objects of the collection that are not frequently consulted or used. Additionally, it was proposed that visible instructions inside the cupboard should be provided to remind users to open and close the drawers carefully to avoid vibrations that could affect the fragile condition of the human remains inside.

Conclusions

The treatment, which involved exclusively preventive conservation measures including the use of inert and stable materials, contributed to an improved condition and ensured the safe storage and long-term preservation of the mummified hand and associated objects. The simple construction and manufacture of the support system can easily be reproduced to be suitable for other items in the British Museum collection. The supports were adapted to the physical needs posed by their condition and also took into account spiritual and religious beliefs as regards to the wooden cylinder. Although these aspirations could not be fully realized, both the hand and the cylinder were finally reunited in the same box.

Human remains	Desirable conditions		Acceptable conditions	
	Relative humidity (%)	Temp (°C)	Relative humidity (%)	Temp (°C)
Ancient Egyptian mummies	35–45 (daily variation < ± 3)	16–20 (daily variation < ± 2)	35–45	16–25
Bog bodies (Lindow Man)	50–60 (daily variation < ± 3)	16–20 (daily variation < ± 2)	50–60	16–25
Skeletal material	40–55 (daily variation < ± 5)	16–20 (daily variation < ± 2)	40–60	16–25

Table 1 An outline of both the desirable and acceptable storage and display conditions for human remains

The importance of condition assessment by survey

A survey of a collection in storage or on display determines its condition and classifies the urgency of conservation care (see Appendix 2 for an example of a survey form). From this a recommendation can be made as to the treatment required and other resources necessary such as available expertise, conservation materials, time and storage requirements. For example, due to the range of materials found in the burial ensembles of ancient Egyptian mummies, assessment of this material requires a broad range of conservation skills, including those relating to human remains, textiles, wood, painted surfaces and metalwork.

For skeletal material, several surveys have been carried out on British Museum material (Ward 2003) and also on material for other museums (see Cook and Ward 2008). Such surveys have demonstrated the range of old adhesives used in the past and problems encountered by their use (Monge and Mann 2005) and in addition, the damage caused by researchers using moulding materials and metal measuring instruments. This may have involved application of a material directly onto or into the bone, or an indirect intervention using a specialized supportive system.

For naturally mummified human remains, the survey of the Fourth Nile Cataract human remains is particularly relevant (Wills *et al.* 2010). The survey aimed to understand the condition of the bodies and the range of materials present so that bodies could be stored appropriately and be made available for study. Those that were suitable for CT scanning were also identified. The survey was able to record the present condition as a benchmark for the future and began to identify material that would benefit from additional research such as textiles, body markings and hair. It also acted as a post-excavation assessment as the material had come almost directly from a rescue excavation. The potential for storage improvements was assessed, offering suggestions for upgrading the support boards, providing good soft supports for vulnerable tissues, removal of loose soil and identifying, bagging and labelling sample material.

Maintaining conditions in storage and on display

The best strategy for the long-term preservation of human remains centres on well-planned storage and display solutions that specifies appropriate housing and materials in addition to the maintenance of stable environmental conditions. A handling protocol for those studying or working with the collection should also be in place and referred to before study or handling (see Chapter One, this volume). At the British Museum, the preservation strategy for all collections, including human remains, is to prevent or slow down damage that may be caused by various factors including inappropriate temperature or relative humidity, light, dust, pollutants, pests and physical forces such as handling, abrasion and vibration. The recommended environmental conditions for organic material are generally considered to be a relative humidity of 50% (+/-5%) and a temperature range of 16–25°C (Saunders 2006). However, materials that have adapted to environmental conditions different to these and are in good condition should be kept in those conditions. In particular, desiccated material should be kept at lower relative humidity levels (e.g. ancient Egyptian mummies are stored at around 40 +/-5% in the British Museum) otherwise they might deteriorate, whereas bog bodies require a more humid environment (relative humidity 50–60%). Daily variations in environment both in storage and on display should be kept to a minimum. Acceptable and desirable conditions are shown in **Table 1**. Mechanical conditioning units to control humidity levels are employed both in showcases and in stores at the British Museum. Temperature and relative humidity in different locations are monitored using Hanwell telemetric sensors to check that conditioning units are working correctly.

Human remains should be stored in the dark when they are not exhibited. Light levels should, as far as possible, be below 50 lux when such material is on display, with a cumulative light exposure of 150,000 lux.h.year^{-1} (i.e. 1,500,000 lux.h.year^{-1} in any 10 years) and an ultraviolet level of 75 μW.lumen^{-1} or less to minimize the fading of soft tissue when present (Saunders 2006). This is achieved by selection of the appropriate types of lamp, modifying showcases in order to screen out light and by dimming in-case lights. If the remains are skeletal, a maximum of 200 lux is acceptable.

Indoor pollutants such as acidic vapours and sulphur-based gases can be released from some storage and display materials. In enclosed spaces, these pollutants are able to build up to levels that can damage human remains and associated objects. Dust can also damage remains by soiling surfaces and creating hygroscopic layers which are sometimes acidic or alkaline. At the British Museum, these and other vulnerable collections are protected from dust and pollutants by being displayed in well-sealed showcases and packed in appropriate materials for storage or transportation. All materials used for the storage and display of collections are tested prior to use to ensure that they are inert (Thickett and Lee 2004).

Human remains are very vulnerable to damage from insect pests such as clothes moths and carpet beetles. However, different pests can be attracted to the protein and cellulose-based materials found in the human remains collections, and good housekeeping, inspection and monitoring routines are essential. The British Museum has an integrated pest management (IPM) programme to protect collections (British Museum 2010), with high risk materials receiving particular attention.

Packing for transport

Transport of any human remains is required when they are loaned to other institutions for display or moved to facilitate research such as CT scanning. The mummies held within the Department of Ancient Egypt and Sudan are consistently popular with the visiting public and scholars, both on display in London and for loan nationally and internationally. Mummies chosen for long-term loan have to be both robust and stable. The British Museum uses a standard packing system based on wooden crates lined with expanded polyethylene foam padding and Plastazote cut-outs wrapped in Tyvek (see Chapter Five, this volume).

For fragile specimens such as spontaneous mummies however, additional packing is required. The human remains are placed on a 'mattress' created by filling a cushion made from Tyvek with polystyrene balls. Both the mattress and the human remains then rest on a stable baseboard covered with Tyvek. A number of thin polythene bags filled with polystyrene balls are placed around the perimeter and above the body. These can be given different qualities dependent on how much air is expelled. Lots of air within the bag allows the balls to move and flow. Expelling air when sealing results in cushions that are 'mouldable' and hold a given shape. The more air expelled, the harder the cushions. Soft bags are placed against the body; harder, mouldable ones around the edges to keep these in place.

A disadvantage of this packing system is that, as they move, polystyrene balls readily generate static electricity, cling to a variety of surfaces and may therefore adversely affect fragile objects. The charge can be minimized by earthing the bags or using an anti-static gun. High humidity will dissipate any charge, as will a conductor such as metal. Simple handling and leaving the bags for a while will also allow the static charges to fade, or using Tyvek treated with an anti-static agent. In low relative humidity however, all types of Tyvek will build up a static charge, as will polythene bags.

Conclusions

Human remains are often found in a fragile state and therefore may require some kind of physical support during handling. In the past this was often achieved by the use of resins and other materials in order to strengthen the human remains. Incorrect reconstructions also occurred. The materials used can deteriorate and cause damage, while often failing to provide the necessary support and affecting potential analyses. The removal of old resins, adhesives and fills may be important in the survival and proper interpretation of the human remains. This can be a difficult and thoughtful process that requires research to analyse and understand the aged restoration material and and requires sensitivity to implement its removal and replacement.

The current approach adopted by conservators at the British Museum is to support fragile material where possible by the use of external physical supports and to encourage careful handling. When adhesives, consolidants and fills are required, their use is kept to a minimum. Any conservation materials used must have been tested and proved to be stable and reversible or retreatable. All treatments are carried out in close liaison with the appropriate curator or physical anthropologist, which is necessary in both understanding the human material and facilitating study. A record of all conservation treatments is maintained within the Museum's Collection Online database.

The British Museum contains many different types of human remains recovered from a diverse range of cultures, periods and environments. The bodies are an important source of direct information about our ancestors and therefore our approach to conservation is to maximize the survival of these remains and to ensure that they can be accessed safely and with respect.

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Appendix 1 Example of a British Museum Risk Assessment Form

Severity

Likelihood	Low	Medium	High
Low	Low	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Likelihood (L) x Severity (S) = Risk (R) (high, medium, low)

This RA is specifically designed for the Senior Clothworkers Fellowship Project: Safeguarding a body of evidence: researching and conserving a group of exceptional naturally mummified Nilotic human remains. It is adapted from the General / Job or / Area specific Assessment for controlling the risks of infection at work from human remains, carried out by Claire Messenger and Tania Watkins (AES) with specific advice from Betina Jakob, Physical Anthropologist, University of Durham. A 2007 review carried out by Sherry Doyal and Clare Ward based on advice sought from: Bill White, Curator Centre for Human Bioarchaeology MOL; Natasha Powers, Head of Osteology, MoLA; Martyn Cooke, Head of Conservation, the Royal College of Surgeons of England; Pat Potter, British School of Leather Technology, 2004. Also referencing 'Controlling the risks of infection at work from human remains' HSE 2005; 'Anthrax and historic plaster-technical advice note' English Heritage 1999 *Crypt Archaeology: an Approach*: Institute of Field Archaeologists Paper no. 3; www.bt.cdc.gov/agent/smallpox/vaccination/faq.asp. Further information is derived from attending a Hazards in Museum Collections course 17/11/11. Advisor was Else Bourguignon, H&S specialist, Conservation and Scientific Research. Also http://www.who.int/csr/resources/publications/anthrax_webs.pdf, chapter 4.2 Susceptibility: data for risk assessments; WHO publication 2008, p37. Also http://www.hse.gov.uk/pubns/web01.pdf: Controlling the risks of infection at work from Human Remains (Health and Safety executive).

TASK/ ACTIVITY AREA	**HAZARDS**	**WHO'S AT RISK**	**CONTROLS IN PLACE**	**L**	**S**	**R**	**FURTHER CONTROLS NEEDED**	**WHO TO ACTION**	**COMPLETION DATE**
The cleaning, support, sampling and study of c. 40 desiccated, recently excavated and naturally-mummified bodies from the Fourth Cataract region of the Nile. Housed in room 60. Fellowship runs over a period of 2 years (part time). Date range 6th to 15th C AD.	Infectious disease (microbial agents or bacterial) from bodies. Risks posed by anthrax and smallpox Soil and other material (textiles, jewellery etc.) associated with bodies.	All staff in contact with material; primarily B Wills and any co-workers.	Likelihood of disease very small ('very remote risk') because spores or infectious agents are unlikely to remain viable after 100 years, and less so in a desiccated context. People in contact should be advised of the degree of danger from infection. Personal hygiene of great importance. Keep hands and fingernails clean, avoid hand-to-mouth contact. Wash hands and face after each episode of contact. No consumption of food and drink in proximity. Cover any cuts, wounds and abrasions with waterproof dressings. Personal protective clothing should be routinely worn such as disposable apron, and Tyvec sleeves. Suggest disposable nitrile gloves; dust mask type FFP3. Remove any contaminated PPE when leaving the area. Keep surrounding areas clean and dust free. Waste, including PPE and vacuum bags, should be disposed of correctly by incineration. Ensure that relevant personnel are informed of the risk and risk management strategy.	L	H	L			

TASK/ ACTIVITY AREA	HAZARDS	WHO'S AT RISK	CONTROLS IN PLACE	L	S	R	FURTHER CONTROLS NEEDED	WHO TO ACTION	COMPLETION DATE
As above, focusing on removal of small area of mould on arm of skeleton 353 (3-J-23 Gr 120)	Fungal growth and spores; may be aerated by process of cleaning/ removal.	As above	Refer to mould removal RA. PPE and disposal as above. Minimise aerosol mould: experiment with the use of Groomstick (molecular trap putty) and compare with brush/ vacuum cleaner removal. Fluctuations of humidity in storage/work area have been reduced by boarding up windows that had failed to close. This reduces risk of future mould outbreaks	L	H	L	Check environmental conditions on a regular basis.		
Removing dust and soil.	Inhalation of particles while removing dust from remains.	All staff in contact area.	Raised dust (with brush or photographers bulb puff ball) should be caught with a vacuum fitted with a high efficiency particulate air filter (HEPA filter). As above PPE and disposal. Clean area regularly.	L	H	L	Be aware it is important to ensure that work areas are also kept clean. While removing dust from the find please be aware of where it is going in case it could pose a risk to others.		
Removing dust and soil. Treating bodies as above	Note that at greater risk are those with compromised immunity such as pregnant women, HIV positives and those receiving chemotherapy.	All staff in contact areas who are identified as at higher risk.	All staff have a responsibility to either identify themselves as at risk or to absent themselves from the project. As above regarding PPE and disposal. Clean area regularly. Check health status of any co-workers/students.	L	H	L	No one should assume that colleagues wish to make personal medical detail public. Make sure the risk is clearly posted to allow colleagues to absent themselves.		
Observing physical work with and on human remains	Psychological stress	Staff passing through room 60. Staff in OIII.	Work area is screened off and not easily visible. The entrance to the work area clearly warns those entering, denoting the nature of the work and presence of human material. Issues (ethical and practical) should be fully discussed if requested. Persons should be sure to treat any excavated human remains with appropriate respect, and take steps to ensure other staff or visitors to the department are not offended	M	H	M	Check regularly with staff in OIII that controls are working.		
Physical work with and on human remains	Psychological stress	B Wills	Regular breaks, including informal discussion, should be taken to allow human responses to emotive situations. Human remains treated with respect as above.	M	H	M			

TASK/ ACTIVITY AREA	HAZARDS	WHO'S AT RISK	CONTROLS IN PLACE	L	S	R	FURTHER CONTROLS NEEDED	WHO TO ACTION	COMPLETION DATE
Physical work with and on human remains		Students/ co-workers	All students etc. to be to be fully briefed on the overall project rationale and recruited carefully. To be made fully aware of the task they will be expected to undertake. Human remains treated with respect as above. Issues (ethical and practical) should be fully discussed if requested. Regular breaks and discussions as above.	M	H	M			

Appendix 2 Example of a human remains survey form used by the Conservation Department at the British Museum

Human Remains Conservation Survey

Identification

Reg./Spec. number [ ] Location [ ]
Other numbers [ ]
Surveyor(s) [ ] Date of Survey [ ]
[ ]
Object description [ ]

Dimensions [Length] [Width] [Depth] [Weight]
Provenance [ ] Period [ ]
Photograph (including date and registration number)

[ ]

Photo sequence number [ ]

Description

Body state ☐ skeleton ☐ mummified ☐ other… [ ]
Mummification type ☐ natural ☐ artificial ☐ other… [ ]

Sex ☐ M ☐ F ☐ Unknown Age at death ☐ child ☐ teenager ☐ adult
Position ☐ straight ☐ foetal ☐ other
Body ☐ complete ☐ incomplete ☐ body part ☐ body parts ☐ other…

No. of bones [ ] No. of parts [ ] No. of bags/boxes [ ]

Human tissue/organs [ ]
Tattoos/Scarification/Piercings [ ]
Hair Visible ☐ Yes ☐ No
Hair Location [ ]
Hair Colour [ ]
Teeth Visible ☐ Yes ☐ No Comments [ ]
Associated objects [ ]

Page 1 of 4

Human Remains Conservation Survey

Sketch of the body/ part

Direction
- ☐ Lying on back
- ☐ Lying on front
- ☐ Lying on L side
- ☐ Lying on R side
- ☐ Other..

If other:

Wrappings
- ☐ none
- ☐ leather
- ☐ skin
- ☐ other…
- ☐ fur
- ☐ textile
- ☐ rope/string

weave

fiber ☐ plant ☐ animal ☐ human ☐ unknown

Comment wrappings: e.g., location

Condition

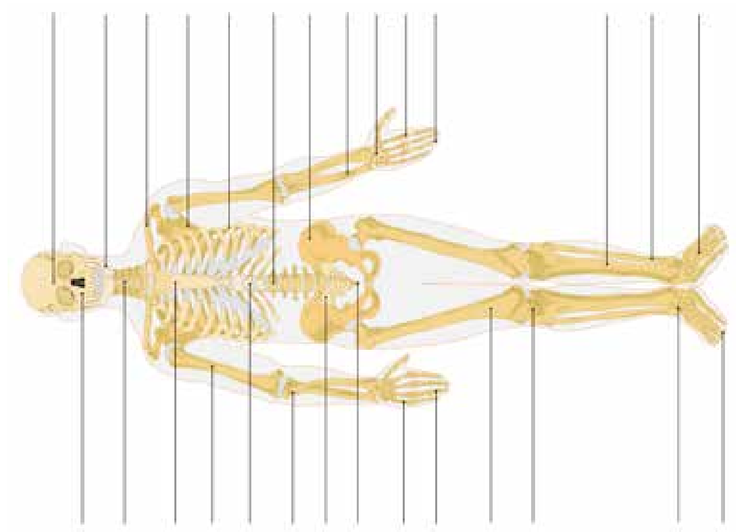
General condition
- ☐ A – no work needed
- ☐ B – low conservation priority
- ☐ C – medium conservation priority
- ☐ D – high conservation priority
- ☐ E – beyond repair

Previous repairs/treatments ☐ yes ☐ no ☐ not known ☐ stable ☐ unstable

Comments on previous treatments

Condition Diagram

Please mark the diagram with condition code keys for bone/skin/hair/wrapping.



State of Preservation - Bone: ☐ 1 = < 25% ☐ 2 = ~ 50% ☐ 3 = > 75%

State of Preservation - Skin: ☐ 1 = < 25% ☐ 2 = ~ 50% ☐ 3 = > 75%

Human Remains Conservation Survey

Bone Condition

Physical damage	☐ b01 – break	☐ b02 – brittle	☐ b03 – crack
	☐ b04 – cut mark	☐ b05 – disarticulated	☐ b06 – displaced
	☐ b07 – holes	☐ b08 – missing parts	☐ b09 – soil

Comments

Skin Condition

Physical damage	☐ s01 – bloom	☐ s02 – crack	☐ s03 – cut marks
	☐ s04 – delamination	☐ s05 – distortion	☐ s06 – efflorescence
	☐ s07 – loss	☐ s08 – metal stain	☐ s09 – soil
Biological damage	☐ s10 – fungae	☐ s11 – insect frass	☐ s12 – insect carcasses
	☐ s13 – mould stain	☐ s14 – pest damage	☐ s15 – other...

Comments

Hair Condition

Physical damage	☐ h01 – loss of hair	☐ h02 – slippage	☐ h03 – breakage
	☐ h04 – other...		

Comments

Wrapping Condition

Physical damage	☐ w01 – torn	☐ w02 – stained	☐ w03 – other...

Comments

Overall Anomalies

Action Priority List

Please prioritise in numerical order (1 = needing most urgent attention)

- ☐ intervention (please specify)
- ☐ cleaning
- ☐ support / secure fragile parts
- ☐ new storage
- ☐ other...

Human Remains Conservation Survey

Current Storage

Description

Proposed Storage

Room

Temperature

RH

Lux

Box

Size ☐ Small ☐ Medium ☐ Large ☐ Other…

Shape ☐ Square ☐ Rectangular ☐ Oval ☐ Round ☐ Other…

Material ☐ Wood ☐ Foam board ☐ Acid free card ☐ Other…
☐ Metal ☐ Coroplast (polypropylene) ☐ Polystyrene foam board

Cover Material
☐ Lid in same material as box
☐ Tyvek (Polyolefin)
☐ Cotton
☐ Polyethylene
☐ Melinex (Polyester)
☐ Acid free tissue
☐ Teflon
☐ Bonina
☐ Hollitex (Polyster tissue)
☐ Other…

Comments

Support

Material ☐ Plastozote ☐ Polyester batting ☐ Polyethylene foam (etafoam)

Cover Material
☐ Acid free tissue
☐ Teflon
☐ Bonina
☐ Hollitex (Polyster tissue)
☐ Other…
☐ Tyvek (Polyolefin)
☐ Cotton
☐ Polyethylene
☐ Melinex (Polyester)

Comments

Location of support needed

Microclimate