Chapter 3
The Scientific Analysis of Human Remains from the British Museum Collection
Research Potential and Examples from the Nile Valley

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The British Museum has nine curatorial departments[1] which manage the Museum's collection, as well as a Department of Conservation and Scientific Research that houses research and conservation laboratory facilities. British Museum scientists, along with the curatorial staff, further the understanding of the collection, together with the cultures and periods from which they originate, through an extensive programme of research and analysis. This chapter will discuss how the scientific investigation of human remains held in museum collections can – with the development of fresh approaches and scientific methods – benefit from new research and continue to further our understanding of the past. It also describes how the British Museum collection is made available to other researchers. The chapter concludes with examples of current research in the Department of Ancient Egypt and Sudan, including new work on long-held collections and the innovative technology used to display the results.

Holding for the future: new advances in scientific analysis

The human remains held in the British Museum collection have been and continue to be part of numerous research projects, initiated by both the Museum and external researchers, and the scientific analysis of these remains is furthering our understanding of past cultures, human biology and ancient diseases (see Part Three, this volume). The importance of the scientific investigation of archaeological human remains has been the subject of much literature (e.g. English Heritage and the Church of England 2005; Bekvalac *et al.* 2006; Mays 2013). A considerable amount of biological information can be discovered through the analysis of skeletal remains (e.g. Buikstra and Ubelaker 1994; Brickley and McKinley 2004; Roberts 2009), mummified remains (see below and Chapter Nine, this volume), or even a single tooth (e.g. Hillson 1996; Antoine *et al.* 2009). This goes beyond simply determining the age-at-death or biological sex of an individual. Human remains can inform us of various aspects of past biology, such as child growth and development, biological affinities between individuals or populations, past diets and the occurrence of ancient diseases or trauma (e.g. Larsen 1997; Roberts 2009; Roberts and Manchester 2005; Waldron 2008). As stated in the *Guidance for the Care of Human Remains in Museums* published by the Department for Culture, Media and Sport (see Chapter One, this volume), 'Many human remains have undoubted potential to further the knowledge and understanding of humanity through research, study and display' (DCMS 2005, 20). New research can help refine or advance previous interpretations, furthering our understanding of the past and allowing new questions to be addressed.

An example is given by the examination of the skeletal remains from the site of Jebel Sahaba, which is central to several projects investigating the early inhabitants of the middle Nile valley, including their biological affinity (e.g. Irish 2005; Crevecoeur 2012). Located near the Second Nile Cataract, this Palaeolithic cemetery was excavated by Fred Wendorf in 1965–6 as part of the UNESCO Aswan High Dam Salvage Project (Wendorf 1968). Along with the associated archives, this assemblage was generously donated to the British Museum in 2001 and now forms part of the Wendorf Collection. The skeletal remains from this site are well known for showing signs of violent death, including several individuals bearing cut marks or found with embedded lithics. Jebel Sahaba is generally regarded as representing the earliest evidence of collective violence or warfare, and is one of the earliest known burial sites in the Nile valley (Anderson 1968; Wendorf 1968; Judd 2007; Antoine *et al.* 2013). The date of the skeletons from Jebel Sahaba was originally determined by radiocarbon dating of the collagen fraction of the bone, a technique conventionally used to avoid cross-contamination with carbonates in groundwaters. However, the collagen was poorly preserved, a common problem in arid environments (Saliège *et al.* 1995; Sereno *et al.* 2008; Zazzo and Saliège 2011) and questions remained as to the reliability of the original date (Antoine *et al.* 2013). The site was recently redated using the apatite fraction – one of the minerals found in bone – instead of the poorly preserved collagen (a protein). The new radiocarbon dates confirmed that the burial site belongs to the Epipaleolithic (i.e. Upper Palaeolithic) period and that the skeletal remains held in the Museum are one of the rare examples of a sizeable population from the Late Pleistocene (Antoine *et al.* 2013).

Other analytical methods now in use were not available 20 years ago – for example, the possibility of studying the genome of ancient pathogens was in its infancy. The study of ancient biomolecules and the extraction of ancient DNA are now allowing us to further investigate the epidemiology of ancient diseases (e.g. Brown and Brown 2011). Schuenemann *et al.* (2013), for example, recently sequenced the genome of *Mycobacterium leprae* in British, Swedish and Danish medieval skeletons with leprosy. While standard archaeological methods provide an insight into the lives of individuals suffering from leprosy, such as whether they were stigmatized and buried in separate burial sites, we can now also directly compare the genetic composition of past and present *Mycobacterium leprae* genomes and study the evolution of such pathogenic organisms (Schuenemann *et al.* 2013). Another technique, stable isotope analysis, has transformed research on ancient diet through the chemical analysis of isotopes found in human tissues such as bones and teeth. Carbon and nitrogen isotopes can reflect the diet during life and are particularly informative when considering the relative intake of marine, plant and terrestrial animal proteins consumed (see Roberts 2009; Brown and Brown 2011), whilst other isotopes such as those of oxygen and strontium, can indicate geographic origin. Older methods are also being superseded or revised, with new radiocarbon calibrations and techniques, like that of apatite dating described above, providing new age estimates (e.g. Roberts 2009, 214–16). High resolution 3D imaging techniques such as CT scanning have revolutionized the use of X-rays to analyse mummified remains. However, while new research is transforming our understanding of ancient human remains, access has to be carefully managed in order to protect collections for present and future generations. Academic publications indicate that human remains held in British institutions play a vital role in research (Mays 2010), but that some museum collections are under an increasing amount of pressure with the majority of work based on only a few skeletal assemblages (Roberts and Mays 2011; Roberts 2013). The scholarly justifications for any destructive sampling must therefore be carefully considered and the British Museum must attempt to balance the competing needs of present day scholars requesting access to the collection, the necessity to preserve material for future generations and the overriding imperative to ensure that human remains are always treated in an ethical and respectful way.

Access to human remains for scientific analysis

The British Museum receives a large number of requests to examine, and often to sample, all types of collection material, including human remains, for scientific purposes. The Museum recognizes the importance of making the collection available to external researchers, so that its artefacts can be included in broader research projects and compared to other collections. While such research is one of the prime justifications for the existence of museums, a fine line has to be maintained between this need and the duty of care implicit in the British Museum Act 1963[2] to protect the collection for present and future generations. As discussed in Chapter One, human remains also require special ethical considerations, as well as great care and respect (e.g. Sayer 2010). When permitting research on this part of the collection, the British Museum reminds researchers of their ethical obligations with regard to human remains and expects them to follow the relevant principles of the British Museum Policy on Human Remains (Trustees of the British Museum 2013, 4).

In order to safeguard the collection, and to ensure that any human material is treated in a suitably respectful manner, all such requests are subject to a rigorous review process following a formal application procedure. Researchers or others visitors wishing to view, study or otherwise have access to human remains in the Museum's collection that are older than 100 years and not on public display are required to apply in writing to the appropriate curatorial department. Before arranging access, the curator responsible for the collection will take into account the merit, feasibility and appropriateness of the proposal, as well as the state of preservation and fragility of the remains. All applications must also comply with the British Museum Policy on Human Remains. For any request involving access to human remains that are, or may be, less than 100 years old, care is also taken to ensure compliance with the Human Tissue Act 2004 and written permission from the Designated Individual named on the Museum's licence is required (see Chapter One, this volume). No requests for access to any human remains in the collection that are the subject of a claim for transfer are considered while the outcome of the claim is pending.

All handling and investigative methods are undertaken in such a way that the risk of contamination which might affect analysis in the future is avoided and copies of all data collected are retained within the Museum records so that unnecessary repeated handling can be avoided. The scientific analysis of human remains forms an integral part of modern archaeological research that sometimes necessitates destructive sampling. The extraction of ancient DNA or stable isotopes, for example, requires the destruction of small amounts of bone or dental tissue. Authorizing destructive sampling should be considered carefully and useful advice can be found in the *Guidance for Best Practice for Treatment of Human Remains Excavated from Christian Burial Grounds in England*, published by English Heritage and the Church of England. Annexe E6 on the 'Ethics of destructive sampling of human remains' (English Heritage and the Church of England 2005, 34) includes several pertinent points that are applicable to all human remains:

- Can non-destructive techniques be used to address the research question(s)?
- Is there a realistic prospect of producing results?
- The area to be sampled should be carefully considered and samples should not be taken from areas that may affect future research. Sampling areas with signs of pathological change should be avoided unless it is the focus of the study.[3]
- Prior to sampling, the bones or teeth to be analysed should be fully recorded, measured and the resultant data inputted into an appropriate database. When possible, and particularly if the skeleton is intended for museum display, researchers should produce a high-resolution impression or cast of the part(s) that will be damaged or destroyed.[4]

As discussed in Chapter One, the Museum keeps a record of all destructive sampling (and the location of any remaining samples) and research on human material that includes any form of destructive sampling[5] requires the completion of a specific application form.[6] In addition to a detailed list of the collection(s) to be accessed or sampled, the form includes sections on the technical reasons for the request and a description of the intended methods of analysis. This must be completed by all external researchers or students, irrespective of whether the examinations/analyses are taking place at the British Museum or off-site, and whether or not they are collaborating with Museum staff. The application form, the application process, the rationale behind it and the conditions that may apply, as well as the assessment criteria, are all available online,[7] together with some examples of the loan conditions which may be applied should the analysis require the human remains to go off site (e.g. for techniques that are not available at the British Museum, such as CT scanning). Decisions as to whether to permit access are based on expert opinions gathered during the review process, which is conducted jointly by the appropriate curator(s), members of the British Museum's scientific team with expertise in the area and, if there are any concerns about the vulnerability of the material to physical damage, by conservation specialists. Colleagues from other institutions may also be called on for advice if necessary, particularly if the application is part of a larger research project with samples requested from other museums.

The British Museum's assessment criteria for analysis

When making an application, researchers are encouraged to make an honest assessment of the likelihood of the success or failure of the project. The information collected is then considered against a number of criteria to assess the suitability of the application. These criteria are listed on the 'Scientific Study of the British Museum Collection' web page and include:

- The scholarly merit of the proposal.
- The feasibility of the project.
- The appropriateness of the proposed scientific techniques/methods to answer the questions posed.
- Experience and expertise of the research team in applying these techniques/methods.
- Previous work undertaken on similar material.
- The fragility of the material in question.
- Sample sizes required in relation to the size and rarity/uniqueness of the object.
- Other immediate or long-term impact on the object(s), including risks associated with exposure of object(s) to ionizing or non-ionizing radiation.
- Experience of the research team in working with museum material.
- Anticipated outputs of the research (publications, etc).
- Health and safety implications.

The samples requested should not duplicate previous research unless there have been significant developments in that particular field or the methods have considerably changed (e.g. new radiocarbon dates may be required if the previous ones are no longer deemed to be reliable and improved techniques have become available). Reviewers must also determine if the proposed project has a defined aim of substantial scholarly merit; if that aim can yield new or more advanced knowledge than currently exists; and if it can feasibly be achieved by the applicants using proven methods. All of this may sound straightforward, but it is not unknown for the destructive sampling of human remains to be requested with few or poorly defined aims that repeat work which has already been reliably carried out, or even for samples to be requested speculatively without guaranteed access to appropriate equipment. Unless the investigation method is totally non-invasive and can be proven to hold no risks for the materials concerned (something which is extremely difficult, given that even unpacking skeletal material can put it at risk, hence jeopardizing potential future research; see below), it is also seldom appropriate for any collection material, and almost never appropriate for human remains, to be used in tests of novel or only partially developed techniques. If an application is made to apply an unusual or novel method to British Museum material, the technique would first need to have been demonstrably proved using suitable test materials and even then small-scale pilot studies on collection material may be suggested as a first step prior to a full-scale study. Factors such as preservation and taphonomic conditions should be taken into account, including whether or not previous research on similar material (e.g. preservation, location or period) has been successful. If an application for access meets these primary requirements, consideration then moves to the suggested methodology and the experience and expertise of the applicants in using these methods.

The Museum has a duty of care to ensure that only the most productive and least destructive techniques are applied to material in the collection, and that any investigation is carried out in a way that does not jeopardize the potential for future research. This can seem severe to individual applicants, who may only have access to a limited range of equipment, but it is nonetheless an ethical necessity. For similar reasons it is expected that research teams demonstrate a track record of success in the use of the techniques to be applied, that adequate provision is in place to ensure that all relevant equipment is available and that they have a good publication record and clear plans are in place for suitable and rapid publication of the results. At this stage, attention is also paid to ensuring that adequate health and safety measures can be put in place to protect both external researchers and British Museum staff. For many applications this is largely a box-ticking exercise, but with increasing reliance on technology and the development of portable equipment using ionizing and non-ionizing radiation (as exemplified by X-ray fluorescence [XRF] and laser scanning respectively) the safety risks can be very real.

Non-destructive methods of examination are always preferred if possible, but it must be remembered that even techniques which appear to be non-destructive may in fact have a considerable negative impact. Something as apparently mundane as opening a box and removing items from a secure storage environment (for details of the types of storage considered appropriate for human remains see Chapters Five and Six, this volume) places that material at increased risk. For this reason handling is kept to a minimum, the condition of the material assessed throughout the process and the use of examination methods which create reliable real or virtual copies of items is encouraged as these may prevent the need for further direct examination. Even those scientific techniques generally termed non-destructive are not always truly non-invasive. The clearest example of this is probably X-radiography, long considered an ideal technique for the study of human remains. Questions are now being asked about the effects of radiation exposure on already fragmented strands of ancient DNA. Research by Grieshaber *et al.* (2008), while not finding any statistical evidence to show that exposure to radiation decreases the amount of amplifiable DNA, did suggest that the doses to which such materials are exposed need to be carefully considered.[8] Similarly, 3D scanning methods can seem an ideal panacea for the study and comparison of form or surface morphology without the need for physical contact, particularly as the data would also then be available for future scholars. However, all scanning methods require some means to measure distances, usually in the form of laser or visible light, and all such interventions have the potential to cause damage, particularly to surface layers. This can be ameliorated by careful control of the intensities used and only levels which fall within the standard British Museum guidelines for light exposures are permitted.

Should sampling be truly unavoidable, a balance needs to be struck between the risks involved, ethical considerations, the importance of the possible results and the size of sample required in relation to the size, rarity or uniqueness of the remains. In some cases it may be concluded that it is better to forgo knowledge for the moment and to wait for the development of new and less destructive techniques rather than to go ahead with the level of sampling currently needed. In all cases only the minimum quantities of material necessary to address the research questions can be justified. Within the British Museum, sampling is always supervised or undertaken by museum staff and is preceded by the recording of the original state of the specimen and accompanied by full documentation (including images) of the sampled areas. When sampling is permitted, the investigators are usually asked to return any material which is not destroyed by analysis to the museum (normally within a year of sampling, although this is negotiable if necessary). Such materials, including chemical extracts and mounted samples, are then available for study by other groups and can alleviate the need for further sampling in the future. Where two or more requests for much of the same work are received, applicants may be asked to collaborate. Collaboration with British Museum scientists may also be suggested, particularly in cases where the Museum has a research interest in the area, the material is very fragile or the suggested analytical equipment/techniques (or more suitable non-destructive techniques) are available in the British Museum's laboratories. The British Museum also requires copies of all results for inclusion in its collection database and retains the right to make all findings available to other researchers five years after they are received, regardless of whether they have been published elsewhere, thus ensuring that data becomes available to other scholars. This right does not exist to deny researchers the fruits of their work, and is not always exercised, particularly if publication is imminent or has been delayed, but is a response to the large amounts of work undertaken on museum objects in the past which has never been disseminated. Ultimately, the British Museum has a duty of care towards its collection rather than to individual researchers and so must seek to make such information publicly available. In an effort to further our understanding of the collection, the British Museum staff are also involved in many research projects, examples of which can be found below and in Part Three of this volume.

Scientific analysis of human remains from the Nile valley

With over 2,000 human remains, the Department of Ancient Egypt and Sudan curates one of the largest collections of ancient human remains in the British Museum (Antoine 2010a). The collection reflects the varied funerary practices and burial traditions of the Nile valley and includes naturally mummified remains preserved by the very dry environment (**Pl. 1**) and intentionally mummified remains from the pharaonic and Roman periods (**Pl. 2**), as well as skeletal remains (**Pl. 3**) from both Egypt and Sudan (e.g. Judd 2001; 2013). A large part of the collection was recovered during the Merowe Dam Archaeological Salvage Project. The construction of a new dam at the Fourth Nile Cataract (in modern Sudan) resulted in a major international rescue campaign during which the Sudan Archaeological Research Society (SARS),[9] in conjunction with the British Museum, excavated several burial sites from the Neolithic to medieval period. As part of a division of finds, a collection of over 1,000 skeletal remains and

Plate 1 Naturally mummified remains of an adult male from the late Predynastic Period *c.* 3500 BC. British Museum, London (EA 32751)

Plate 2 Mummy of an adult woman from the 3rd Intermediate Period wrapped in linen bandages with a glazed composition bead-net, winged scarab amulet and gilded mummy-cover around lower legs. British Museum, London (EA 6697)

naturally mummified bodies was generously donated to SARS by the National Corporation for Antiquities and Museums of Sudan.[10] In turn, SARS donated the collection to the British Museum, where it is now curated. This collection is currently the focus of an extensive research programme that will allow us to gain a unique insight into the inhabitants of the Fourth Nile Cataract region, from the Neolithic to the medieval period. Over the coming years, this should reveal how changes in environment, culture, diet and living conditions may have had an impact on the biology and state of health of the inhabitants of the Fourth Cataract region. This remarkable collection includes over 50 mummies from the medieval period that were naturally mummified by the hot and arid conditions. They have, over the past two years, been the focus of an extensive conservation programme using passive methods (i.e. that avoid chemicals and consolidants) so as not to affect their future research potential (see Chapter Six, this volume). These mummies are also part of larger, mostly skeletonized, assemblages and their analysis is adding to the physical anthropology data derived from the skeletons and revealing aspects of the medieval period that do not usually survive in the archaeological record. This includes unique examples of medieval Christian tattoos (**Pl. 4**) and wonderful textiles. Unlike most Egyptian pharaonic and Roman mummies, the Fourth Nile Cataract mummies were preserved by chance and were not eviscerated. CT scans have shown that their internal organs, as well as the contents of their digestive tracts, are still present (Taylor and Antoine 2014). By analysing their skin, hair and internal organs, we are now building a picture of the medieval period that goes beyond the data derived from skeletal remains and should provide unique insights into body adornment, soft tissues pathology, diet and parasitology.

Plate 3 Early Dynastic burial of an adult male from Tarkhan, Egypt, 1st Dynasty, *c.* 3000 BC. British Museum, London (EA 52887)

The analysis of the skeletons from these sites is also revealing valuable biological information, including evidence of pathological abnormalities rarely described in the archaeological literature. Several skeletons from site 4-L-2 (*Kerma ancien* Period, 2500–2050 BC) have smooth-walled lesions on the bodies of the vertebrae that make up the neck, the cervical vertebrae. Tortuosities and aneurysms, two abnormalities of the vertebral artery, are the most likely cause of such lesions. Indeed, the vertebral artery, which passes along both sides of the cervical vertebrae, can occasionally become dilated, coiled or looped. The tortuous segment – or tortuosity – can cause a pressure defect in adjacent vertebrae, as can the localized enlargement triggered by the weakening of the arterial wall in an aneurysm (Waldron and Antoine 2002). In both conditions, the adjacent bone reacts to the pressure exerted by the abnormally shaped artery by moving away, thus creating a smooth-walled lesion. This is often accompanied by an enlargement of the holes that guide the artery along the side of the cervical vertebrae, the transverse foramen (see Waldron and Antoine 2002; Antoine 2010a; 2010b). Without the preservation of soft tissues, differentiating between

Plate 4 Example of a Christian tattoo from medieval Sudan (left) found on the upper leg of a naturally preserved adult female mummy (site 3-J-23; SK140) and enhanced using infrared reflectography (right), *c.* AD 700. It represents a monogram (motif made by combining and overlapping letters) of the Archangel Michael and is one of the first known surviving examples of tattoos from medieval Sudan. British Museum, London (EA 83133)

tortuosities and aneurysms can be difficult as they can both affect the cervical vertebrae in the same way. These abnormalities are linked to pathological changes in the arterial wall (such as the build-up of cell debris or fatty materials like cholesterol), trauma to the neck or may be congenital in origin (Waldron and Antoine 2002).

Other examples from the Nile valley have been found at Hierakonpolis[11] (C-Group, 2055–1700 BC; Antoine 2010b) and Kawa[12] (Meroitic, 400 BC–AD 400; Antoine 2010a), and apart from a few additional sites (e.g. Waldron and Antoine, 2002), these lesions are seldom reported on in the archaeological and anthropological literature. This is probably due to the relatively subtle changes associated with such abnormalities and, without the careful analysis of the cervical vertebrae, evidence for them is likely to be missed. In order to gain a clearer idea of the prevalence of such lesions, many sites and collections would need to carefully reanalysed, once again highlighting the importance of maintaining research collections. The data collected to date, particularly on the skeletons recovered from the ongoing British Museum excavations at Kawa, suggest that a higher than expected percentage of young individuals (20–35 years old at death) were affected by abnormalities of the vertebral artery. This differs from the patterns observed in modern populations, where these abnormalities (particularly tortuosities) are found in fewer, and usually older, individuals (Waldron and Antoine 2002). Further work is required to investigate why this might be and the possible reasons behind differing epidemiological patterns.

Modern analytical techniques such as CT scanning are only now advancing our understanding of long-held parts of the British Museum collection, some of which were added many decades ago and have been on display for over a century. The body of a man who was buried during the late Predynastic period in about 3500 BC at the site of Gebelein in Upper Egypt, for example, is on display in the Early Egypt Gallery (Room 64). Known as Gebelein Man,[13] he was placed in a crouched position in a shallow grave (**Pl. 1**) and the arid environment, as well as direct contact with the hot sand, naturally dried and mummified his remains. This remarkably well-preserved mummy offers a unique insight into the funerary practices of the late Predynastic era, a period that precedes the unification of Egypt in around 3100 BC.[14] Chance discoveries of such well-preserved bodies in ancient times may also have encouraged the belief that physical preservation was a necessary part of the afterlife and may have encouraged ancient Egyptians to develop the practice of artificial mummification. Gebelein Man has been in the British Museum collection for over 100 years and on display for much of that time, but very little was known about him. In 2012 he was CT scanned for the first time and high resolution X-rays were used to create 3D visualizations so that his muscles, bones, teeth and internal organs could be carefully examined. A virtual autopsy table,[15] an

Plate 5 The Virtual Autopsy display next to Gebelein Man (left) in the Early Egypt Gallery with a close up (right) of the interactive touchscreen and the secondary display screen above it

Plate 6 The 3D visualization display of the CT scan of Gebelein Man (top) allowed visitors to virtually remove layers and observe the excellent preservation of the underlying muscles and skeleton (bottom)

Plate 7 A virtual cutting plane revealing Gebelein Man's remarkably preserved 5,500 year old brain

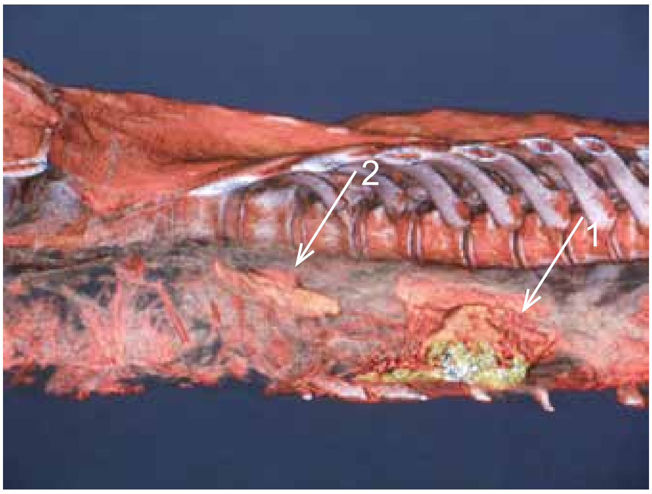

Plate 8 Cutting plane revealing the excellent preservation of Gebelein Man's internal organs, including what appears to be his lungs (1) and one of his kidneys (2)

interactive tool based on medical visualization, was used to convey the results of the research to the public in a new Room 64 display next to Gebelein Man (**Pl. 5**). This temporary exhibition[16] allowed visitors to explore for themselves true 3D visualizations (as opposed to animations) of the original CT scan data by using an interactive touchscreen. The software made it possible to separate the different tissues of the body, allowing users to virtually remove the skin, revealing the remarkably well-preserved underlying muscles (**Pl. 6**) and analyse the skeleton. The cutting function let visitors discover that his extraordinarily well-preserved brain (**Pl. 7**) was still present in the skull and internal organs (**Pl. 8**), often removed when the ancient Egyptians began to artificially mummify bodies, were clearly visible. Information points at relevant locations in the 3D models were used to guide the visitors, allowing them to discover the more significant findings (**Pl. 9**). The morphology of his pelvis (**Pl. 10**) confirmed he was a male and fusion lines on the head, the humerus and the femur indicate that he was a young man of probably 18–21 years old when he died (**Pl. 11**). Consistent with his age, his teeth, fully visible for the first time, showed light wear and he had no apparent dental problems. These new scans also allowed us to visualize something more unexpected. A cut in the skin over his left shoulder blade and the apparent damage to the underlying bone (**Pl. 12**) had never been explained and may have occurred post-mortem. Indeed, many of the bones appear to have been broken after burial and the skin is cracked in a number of places, probably as a consequence of the rapid desiccation that preserved his body. Nonetheless, the 3D visualization of the CT scan shows that the cut on the shoulder blade was different and goes beyond the skin and into the muscle tissue (**Pl. 13**). It was probably caused by a sharp pointed object 1.5–2cm wide and the force of the blow was such that it also damaged the underlying scapula (**Pl. 14**) and shattered one of the ribs immediately below it, embedding bone fragments into his muscle tissue (**Pl. 15**). The fragmentation pattern, particularly that of the rib, indicates that the damage occurred when the bone was fresh, as dry bone usually breaks in a different way. A lot of force would also have been required to shatter the rib into such small fragments. The analysis of ancient human

Plate 9 One of 14 information points built into the interactive display to help visitors discover some of the significant findings

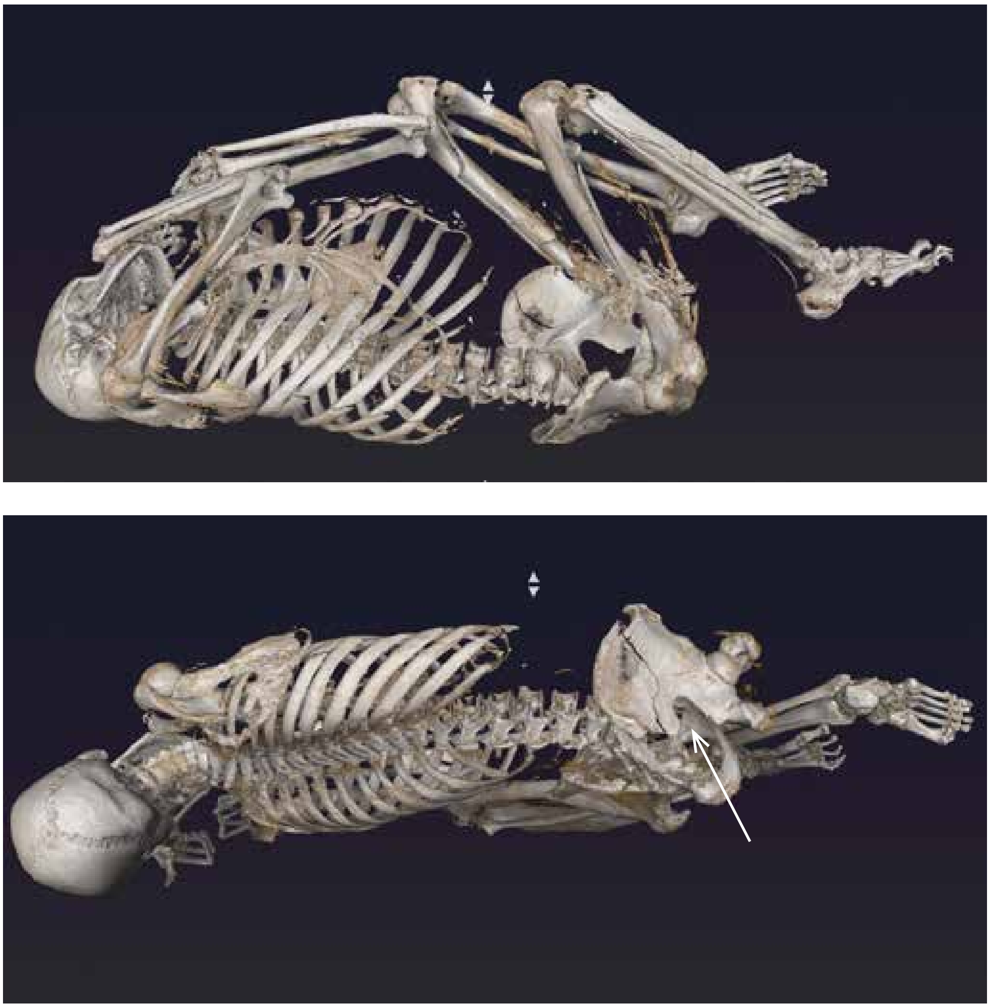

Plate 10 Imaging Gebelein Man's skeleton (top) revealed that numerous bones had been broken post-mortem. The pelvis (bottom) has a male morphology, including a narrow sciatic notch (arrow)

remains rarely reveals the cause of death, but the cut on his back, as well as the damage to the shoulder blade and rib, are characteristic of a single penetrating wound.[17] The weapon is likely to have penetrated into his left lung and may have damaged the surrounding blood vessels. There is no other evidence of trauma or defensive wounds, and the absence of any signs of healing, as well as the severity of the injuries, suggest that this can be considered to be the cause of death. Based on the forensic analysis, the weapon would have been approximately 1.8cm wide at the rib (**Pl. 16**). As the cut was clean and the skin is not lacerated, the weapon was probably not a projectile point, such as an arrow or spear-head, which would have damaged the skin further when removed. Flint knives are also too wide to fit the forensic evidence and a metal blade is the most likely weapon. Metal knives from that period were mainly made of copper and silver, and are rarely found because the precious metals would have been recycled rather than discarded (Friedman and Antoine 2012). Weapons were symbols of power and status and were often depicted in the art of this period as well as being commonly found in graves, but evidence of actual violence is rare (Friedman and Antoine 2012). The lack of defensive wounds suggests the injury was not the result of warfare and may have been caused by interpersonal violence. Gebelein Man has been on display for many decades, but it is only now through the use of science and modern technology that we are beginning to understand more about him. Not only have we been able to

Plate 11 The fusion line on the head of the femur (arrow) indicates that this bone was in the process of completing its growth. Based on modern fusion times, he was most probably between 18 to 21 years old when he died

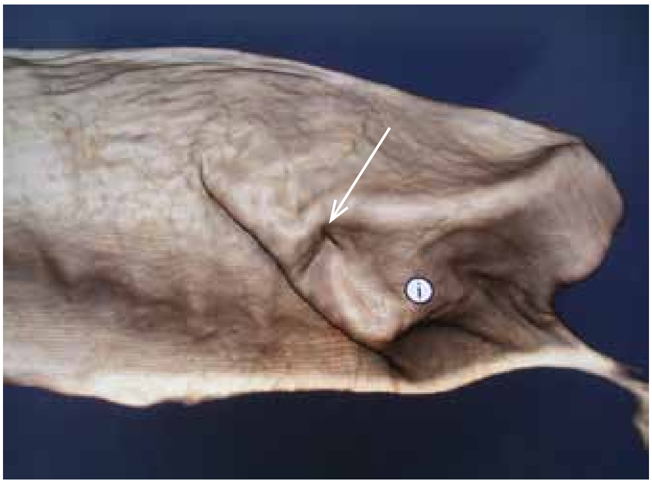

Plate 12 Cut mark (arrow) on the damaged left shoulder blade

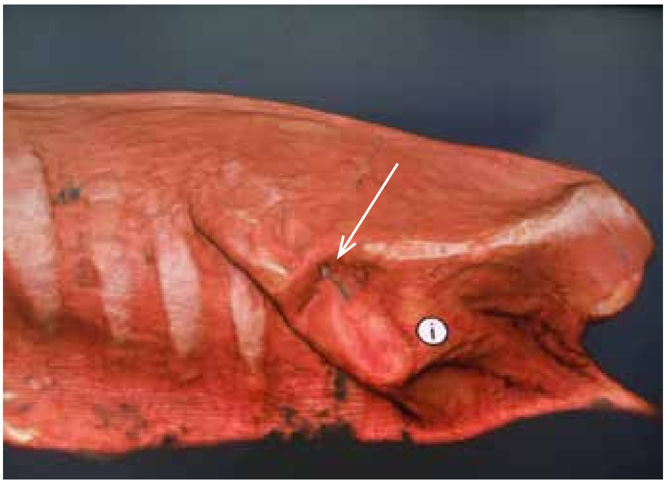

Plate 13 Internal view revealing how the cut (arrow) penetrates into the muscle tissue of the left shoulder blade

Plate 14 The bones immediately below the cut (arrow) are damaged, with the scapula (shoulder blade) broken in several places

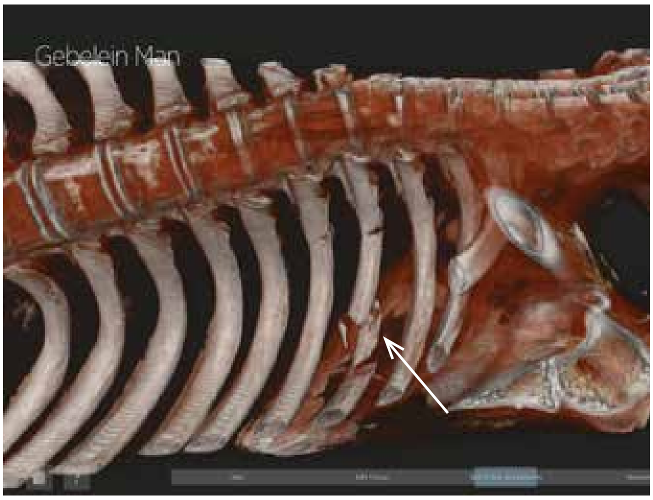

Plate 15 View from inside the chest cavity directly under the cut (arrow) and damaged shoulder blade. The area of the 4th rib immediately below the entry site is shattered into small angular fragments, suggesting a high velocity impact normally associated with a direct hit on fresh bone

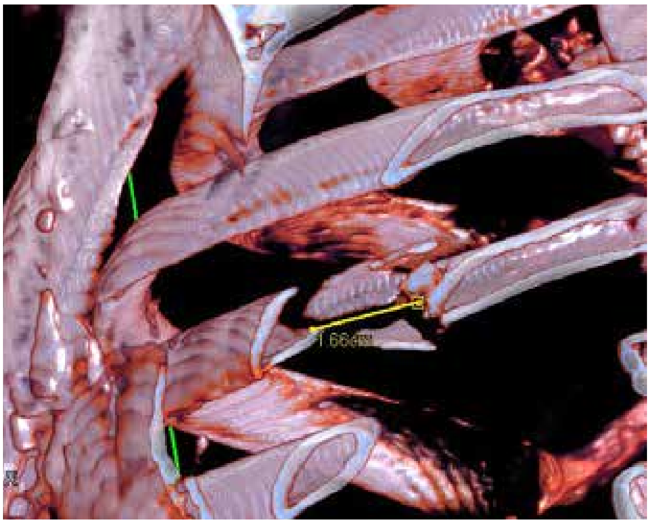

Plate 16 Detailed view of the damaged 4th rib showing the approximate width (yellow) of the damaged area. Measurements suggest the weapon used was 1.5–2cm wide at the rib level (image courtesy of Professor Anders Persson)

discover that he was young when he died but, unexpectedly, he appears to have been stabbed in the back. He is also remarkably preserved, offering the possibility of studying organs that were usually removed in later intentionally mummified remains. Importantly, the virtual autopsy table has also allowed visitors to explore the CT scan data interactively and discover for themselves how we have been able to gain this information and improve our understanding of life in Predynastic Egypt.

Conclusions

The methods and analytical tools available to researchers and curators are always evolving, allowing long-held collections to be reanalysed and thus refine our understanding of the past. With the emergence of more advanced dual energy CT scanners, for example, we should be able to generate even higher resolution images and perhaps one day virtually read text on objects (e.g. amulets) found within mummy wrappings. Some of the British Museum mummified remains are currently being analysed using this new generation of CT scanners, which will increase our understanding of ancient Egyptian funerary practices and generate more detailed information on the biology of the inhabitants of the Nile valley (Taylor and Antoine 2014). The analysis of human remains must be managed in a way that protects collections for future generations and, mindful of their ethical obligations, museums must make sure that the human remains held in their care are always treated with respect and dignity (see Chapter One, this volume).[18] New research also offers an opportunity to share discoveries with British Museum visitors and describe the methods used to analyse ancient human remains, as well as the information such methods allow us to access. Highlighting the importance of research and the role that human remains can play in our understanding of the past is an essential part of the dialogue museums should be having with the public if they are to continue to receive support for the display and scientific analysis of human remains in their collections.

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Notes

1 http://www.britishmuseum.org/about_us/departments.aspx.
2 http://www.legislation.gov.uk/ukpga/1963/24/contents.
3 The following areas should be avoided: all standard osteological landmarks, the mid-point of long-bone shafts or joint surfaces. Complete cross-sections, rendering maximum length/width/breadth measurements obsolete, should not be allowed (i.e. bones should not be cut in half).
4 For robust bones and teeth, impressions may be taken following the method described in Hillson (1992).
5 This also includes any non-destructive analysis that uses radiation sources outside the 400–700nm (visible light) range and exposure to light levels above 500 lux (other than the use of simple photographic flash lights).
6 EE2 Application to Conduct Scientific Analysis of British Museum Collection Material.
7 http://www.britishmuseum.org/the_museum/departments/conservation_and_scientific/facilities_and_services/collection_scientific_study.aspx. Applications should be made on form EE2 (downloadable from the right hand side of the page).
8 In the case of the Jericho skull (Chapter Eight, this volume), this was considered before the CT scanning. The date of the cranium and the nature of the modifications made destructive sampling for DNA analysis not advisable and scanning was recommended.
9 http://www.sudarchrs.org.uk/index_links.htm.
10 http://gmsudan.com/20110408/the-national-corporation-for-antiquities-museums-ncam/.
11 http://www.hierakonpolis-online.org/.
12 The site of Kawa is located between the Third and Fourth Nile Cataracts in modern Sudan and is currently being excavated by Derek Welsby from the British Museum, in conjunction with the Sudan Archaeological Research Society. The site was occupied from the reign of Akhenaton (mid-14th century BC) until the 4th century AD and the excavation of the Kushite phase (800 BC–AD 400) is ongoing.
13 http://www.britishmuseum.org/explore/highlights/highlight_objects/aes/p/gebelein_man.aspx.
14 http://www.britishmuseum.org/explore/highlights/article_index/a/ancient_egypt_the_predynastic.aspx.
15 http://www.britishmuseum.org/whats_on/past_exhibitions/2012/virtual_autopsy.aspx and http://www.britishmuseum.org/channel/exhibitions/2012/virtual_autopsy_gebelein_man.aspx.
16 The Virtual Autopsy was on display in Room 64 from 16 November–3 March 2013 as part of a very successful trial and will return on permanent display in 2014.
17 The findings were confirmed by forensic expert Professor Anders Persson of the Center for Medical Image Science and Visualization: http://www.cmiv.liu.se/.
18 Additional advice on the scientific analysis of human remains and guidance on best practice regarding destructive sampling can also be found in several online documents including the *Guidance for the Care of Human Remains in Museums* (DCMS 2005), *Guidance for Best Practice for Treatment of Human Remains Excavated from Christian Burial Grounds in England* (English Heritage and the Church of England 2005) and, in particular, *Science and the Dead: A Guideline for the Destructive Sampling of Archaeological Human Remains* (Advisory Panel on the Archaeology of Burials in England 2013, http://www.archaeologyuk.org/apabe/Science_and_the_Dead.pdf).

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