PART 1

An introduction to the scientific study of mummies

CHAPTER 1

The background of the Manchester Mummy Project

Rosalie David

Early investigations

From the Renaissance, Egyptian mummies have attracted the interest of antiquarian collectors, who brought them from Egypt to enhance the collections of museums, learned societies, and wealthy individuals in Britain, Europe, and later the United States of America. From the sixteenth century onwards, some of these mummies were 'unrolled' (unwrapped) at frivolous social events in front of invited audiences. Most of these unwrappings had little scientific value; however, some were performed by serious investigators whose detailed publications still provide valuable evidence.

These researchers include Thomas Pettigrew (1791–1865), a London surgeon who unwrapped a series of mummies in London (Pettigrew 1834); Augustus Bozzi Granville (1783–1872), another London doctor who reported evidence of ovarian disease in an Egyptian mummy (Granville 1825); and members of the Leeds Philosophical and Literary Society, who undertook an interdisciplinary study on a mummy in 1825 (Osburn 1828).

In the early twentieth century, various pioneering projects laid the basis for mummy research. Armand Ruffer, Professor of Bacteriology in Cairo, developed methods of rehydrating ancient tissues (Ruffer 1921), and invented the term *palaeopathology* for the study of disease in ancient populations.

Grafton Elliot Smith, Professor of Anatomy in Cairo, performed extensive examinations of the mummies of the rulers of the New Kingdom, discovered at Thebes in 1871 and 1898 (Smith 1912). With his co-workers W. R. Dawson and F. W. Jones, Smith also undertook an important study on some 6,000 ancient bodies retrieved during the Archaeological Survey of Nubia, a heritage rescue operation that was established when the first dam was built at Aswan in the early twentieth century (Smith and Wood Jones 1910). A third scientist, Alfred Lucas (1867–1945), also based in Cairo, performed analyses

of many ancient materials and substances, and was the first to demonstrate that Herodotus' account of mummification was accurate.

Mummy research has progressed steadily throughout the twentieth century, although this development has not shown any continuous or regular pattern. Nevertheless, the route has been highlighted by many important studies which are too extensive to list here, but the following provide just some examples.

Continuing research on royal mummies has included a radiological survey (Harris and Wente 1980), an interdisciplinary study of the mummy of Ramesses II (Balout and Roubet 1985), and various investigations of the mummies of Tutankhamun and the body found in Tomb 55 in the Valley of the Kings. An extensive radiological survey of nonroyal human remains in other major collections (Dawson and Gray 1968) has formed the basis for many subsequent studies, and much information has been derived from the series of autopsies and scientific studies undertaken in the 1970s on several mummies in the Detroit Institute of Art, Pennsylvania University Museum, and the Royal Ontario Museum in Toronto (Cockburn and Cockburn 1980).

The role of the Manchester researchers can now be considered within the context of these earlier and contemporary projects.

Autopsy of the Two Brothers at Manchester

The pioneering work of Dr Margaret Murray at the University of Manchester characterised the new approach to examining mummified remains that emerged in the early twentieth century. As the first curator of Egyptology at the Manchester Museum, she undertook one of the earliest scientific investigations of Egyptian mummies, heading an interdisciplinary team of specialists in anatomy, chemical analysis, and textile studies.

In 1908, before an invited audience in the University's Chemistry Theatre, the team unwrapped and performed autopsies on the mummies of two brothers from a tomb (c. 1900 B.C.) at Der Rifeh. The results of subsequent medical, scientific, and archaeological investigations, which provided information about the tomb, bodies, and funerary possessions, were published in a book (Murray 1910).

The Manchester Mummy Project: initial phase (1973–1979)

Shortly after I was appointed in 1972 to curate the Egyptology collection at the Manchester Museum, I initiated a similar investigation. The Manchester Mummy Project, as it became known, was established to examine all

the Egyptian mummified remains at the museum, although eventually it also encompassed collections held in other institutions. A rare set of circumstances – a university museum with a significant mummy collection, located near teaching departments and hospitals with sophisticated, specialised equipment, and supportive university authorities – ensured that the project had unprecedented access to extensive scientific resources.

An interdisciplinary team of specialists, drawn from the university and associated teaching hospitals, had the primary aim of establishing a methodology for examining mummies based on the availability of a range of techniques and specialist equipment that could be used under near-ideal conditions. Subsequently, other researchers have been able to utilise all or some of the approaches and principles set out in this 'Manchester Method,' to form the basis for their own contributions in this field (Dawson et al. 2002; Taylor 2004; Raven and Taconis 2005).

In examining this group of mummies, the team's second aim was to gain as much information as possible about disease, diet, living conditions, the process of mummification, and religious and funerary customs in ancient Egypt (David 1997).

Techniques used in the first phase of the project (1973–1979) included a radiological survey; rehydration and processing of mummified tissue to produce histological sections that could be examined by light and electron microscopy to demonstrate the framework and cellular detail of the tissue and any evidence of disease; electron microscopy to identify insect remains associated with the mummies; palaeo-odontology; the development and application of special fingerprinting techniques; and the scientific reconstruction of selected mummified heads. In addition, experiments were undertaken to investigate the actual process of mummification, and to assess the accuracy of ancient literary accounts.

In 1975, it was decided to unwrap and perform an autopsy on one of the mummies, Number 1770, in the Manchester collection, to demonstrate how these techniques could provide maximum information about the mummy. As the first scientific autopsy of a mummy in Britain since Murray's project some seventy years earlier, it attracted considerable media interest.

Additional methods of analysis included the macroscopic and microscopic examination of the textiles associated with this mummy; chromatography to isolate and characterise the substances applied to the bandages; and radiocarbon dating to establish and compare the approximate age of the bones and bandages.

This first phase was published in a scientific book (David 1979) and a more general account (David 1978). In 1979, an international symposium entitled *Science in Egyptology* attracted more than 100 delegates to the University

of Manchester to discuss the application of medical and scientific techniques to Egyptological projects. Although earlier Egyptology conferences had sometimes included sessions on palaeopathology, and some scientific meetings had surveyed disease in ancient man, this was a new concept because it focused exclusively on the application of science to Egyptology. The joint proceedings of this successful meeting and another symposium held at Manchester in 1984 were published later (David 1986).

The BBC produced a television documentary in the *Chronicle* series that examined the team's research and recorded the autopsy of Mummy 1770. The Audio-Visual Department of the University of Manchester also made two films which demonstrated the Manchester techniques and key events in the unwrapping of 1770. These films, produced for general use in teaching departments, won awards from the British Association for the Advancement of Science. A public exhibition at the Manchester Museum (1979–1980) presented the team's results within the context of Egyptian funerary beliefs and customs; it attracted many visitors, and received the Sotheby's Award in the Museum of the Year Awards (1980).

The Manchester Mummy Project: second phase (1979–1995)

After 1979, the project moved in new directions (David and Tapp 1984). An important decision to promote virtually nondestructive methods of investigating mummies introduced the use of endoscopy as a means of obtaining tissue from inside a mummy for histological and other studies. Also, acting on a proposal made at the 1979 symposium, an International Mummy Database was established at Manchester to gather, store, and respond to requests for research data about disease found in Egyptian mummies in collections across the world.

This phase of the project was recorded in a second BBC *Chronicle* documentary, and another film, made by the Central Office for Information for distribution outside Britain, related how techniques developed for the project also contributed to contemporary forensic work and plastic surgery.

A major redisplay of the permanent Egyptian galleries at the Manchester Museum highlighted the research and results of the Mummy Project and was judged for the Museum of the Year Award, which Manchester won in 1987.

In the 1990s, Manchester's innovative, virtually nondestructive approach led to invitations to examine mummies in other collections. Pioneering research in identifying DNA in mummies (Pääbo 1985) now opened up new possibilities, and in 1992, at the invitation of Professor N. Kanawati of

Macquarie University, Sydney, Australia, the Manchester team undertook pathological and genetic studies on six mummies discovered in a tomb at El-Hagarsa in Egypt (Elles et al. 1993).

In 1989, P. C. Brears, then Director of the Leeds City Museum, proposed that the Manchester team should undertake a new scientific investigation of the 'Leeds Mummy,' which originally underwent autopsy in 1825 (Osburn 1828). The new study gave the Manchester team the unique opportunity to compare their own techniques and results with those of the earlier researchers (David and Tapp 1992).

The Manchester Mummy Project: third phase (1995–present)

A major development in this phase was the establishment, in 2003, of a university specialisation in biomedical Egyptology within a dedicated centre – the KNH Centre for Biomedical Egyptology in the Faculty of Life Sciences at the University of Manchester (UK) (see Chapter 17). This is now the base for the Manchester Mummy Team and its various projects.

The schistosomiasis in ancient and modern Egypt project

Until the mid-1990s, palaeopathological studies had concentrated on detailed investigations of individual mummies or defined groups of bodies, but in 1995, the Manchester researchers were invited to collaborate with scientists in Egypt on an epidemiological project. The scientists were pursuing a ten-year programme, the Schistosomiasis Research Project, designed to identify contemporary epidemiological patterns of a parasitic disease, schistosomiasis, and to find more effective methods of treating the condition.

The aim of this joint study was to construct epidemiological profiles of schistosomiasis in ancient and contemporary Egypt, and then compare the incidence patterns from the twenty-sixth century B.C. to the seventh century A.D. with the modern evidence, thus describing the evolution of the disease over a 5,000-year period. Resources for this study would include evidence of the disease that occurred in mummies, and contemporary infection data collected by the Schistosomiasis Research Project on some 100,000 people living in villages between the north and south of Egypt (Contis and David 1996; David 2000).

Other researchers have used various diagnostic techniques to detect schistosomiasis in mummies, including radiographic examination to identify secondary pathological indications of the disease, and histological investigation of mummified tissue to detect the presence of worms and eggs. The latter

method was used by Ruffer, who first identified the disease in mummies in 1910. More recent studies show the effectiveness of immunological analysis of tissue or bone samples by using the enzyme-linked immunosorbent assay (ELISA). This can detect the presence of circulating anodic antigen (a glycoprotein regurgitated from the gut of the schistosome) in the mummy, which will confirm if the infection was active at the time of the person's death.

To attempt to trace the pattern of schistosomiasis over the millennia, it was necessary for the Manchester researchers to gather data from a large number of mummies, drawn from different locations and chronological periods (see Chapter 15). For this project, it was decided not to use radiography or histology, because the former would be expensive and dependent on access to specialised x-ray equipment, and the latter would be successful only if tissue could be obtained from specific areas of a mummy.

The Manchester researcher, Dr Patricia Rutherford, therefore decided to adopt an immunological approach: she pioneered the use of immunocytochemistry to detect this disease in mummies (see Chapter 8; Pain 2001), and then confirmed the results by means of ELISA and DNA (Chapter 9). Further success was achieved when, for the first time, the DNA of the causative parasite was identified in one of the samples.

The International Ancient Egyptian Mummy Tissue Bank

To ensure that a sufficient quantity of tissue samples was available for this project, the International Ancient Egyptian Mummy Tissue Bank was established at Manchester (see Chapter 15). The bank was initially funded by a research grant from The Leverhulme Trust to collect and store samples (mainly tissue, but also some hair and bone) from mummies held in collections across the world (apart from Egypt, where there are plans to establish a similar tissue bank). The bank thus provides a new resource of specially selected material for ongoing disease studies and other research.

Instrumental methods

In addition to existing techniques, the Manchester group now has access to a range of instrumental methods, involving organic and inorganic analyses, which are available to forensic scientists who wish to investigate ancient and conserved remains and residues (see Chapters 10 and 13).

For example, these mass spectrometric and other protocols are being applied in a unique study to determine if narcotics and pain-relieving agents

were used in religious, medical, and social contexts in ancient Egypt. This study is also investigating the problem of false results produced by contamination, which may arise from mummification methods, environmental conditions, or diagenesis.

The pharmacy in ancient Egypt project

The most recent area of research in Manchester focuses on the use of pharmaceutical treatments in ancient Egypt. This study is supported by a research grant from The Leverhulme Trust, and combines historical and scientific methodology to investigate the therapeutic potential of these regimes (see Chapter 14).

In a pilot study of more than 1,000 prescriptions found in four Egyptian medical papyri, 379 drug substances have been analysed and formatted in the style of the British National Formulary, detailing their active ingredients and therapeutic efficacy. This initial work, comparing the compounding and administration of these prescriptions with contemporary pharmacy, has demonstrated that some 70 per cent of the identified substances used by ancient Egyptian physicians remained in use in the twentieth century A.D. Researchers working on this project include specialists in many fields who have unprecedented access to both the International Tissue Bank and collections of modern and ancient plants in Britain and Egypt. This provides a unique opportunity to use scientific analytical methods to assess the validity of the literary evidence.

These studies are investigating ancient and contemporary plant and inorganic remains from Egypt, identifying any traces of pharmaceutical residues in mummified tissue samples, and tracing the places of origin and the trade routes by which the raw materials may have entered Egypt.

It is hoped that the results of this research will not only revolutionise our understanding of the scope and significance of ancient Egyptian treatments, but will contribute new information to the history of medicine and pharmacy.

CHAPTER 2

Egyptian mummies: an overview

Rosalie David

Historical background

Mummification (the artificial preservation of the body after death) may have been practised in Egypt for more than 4,000 years, and perhaps developed as early as c. 4500 B.C., when Neolithic communities lived in scattered settlements in the Egyptian Delta and along the banks of the Nile. Gradually, these villages merged into larger groups, drawn together by the common need to develop irrigation systems, and eventually, the north and south were ruled as two separate kingdoms. Egyptologists describe this whole era (c. 5000 B.C.–3100 B.C.) as the Predynastic Period.

In c. 3100 B.C., a southern ruler conquered the northern kingdom, unified the two lands, and founded dynastic Egypt. Thousands of years later, an Egyptian priest, Manetho (323–245 B.C.), composed a chronicle of kings who ruled Egypt between c. 3100 B.C. and 332 B.C., and this king-list has survived in the writings of later historians. It divides the reigns of Egyptian kings into thirty dynasties and these, plus a thirty-first dynasty added by a later chronographer, form the basis for the modern chronology of ancient Egypt.

Contemporary historians arrange these dynasties into a series of major periods: the Archaic Period (c. 3100–c. 2686 B.C.), the Old Kingdom (c. 2686–c. 2181 B.C.), the First Intermediate Period (c. 2181–1991 B.C.), the Middle Kingdom (1991–1786 B.C.), the Second Intermediate Period (1786–1567 B.C.), the New Kingdom (1567–1085 B.C.), the Third Intermediate Period (1085–668 B.C.), and the Late Period (664–332 B.C.).

The conquest of Egypt by Alexander the Great of Macedon in 332 B.C. ushered in the Ptolemaic Period. On Alexander's death, Egypt passed to his general who became King Ptolemy I, and his descendants (the Ptolemies) ruled until the death of Cleopatra VII, the last of the dynasty. The next stage

of Egypt's history, when the country was ruled as a province of the Roman Empire, is known as the Roman Period (30 B.C.–641 A.D.).

Source material

Apart from the mummified remains themselves, sources relating to mummification include inscriptions and funerary illustrations, but these generally concentrate on methods of anointing and wrapping. The earliest detailed descriptions of mummification were written by Classical authors who visited Egypt: Herodotus in the fifth century B.C. (*Histories*: vol.2, 86–88; see de Selincourt 1976), and Diodorus Siculus in the first century B.C. (*Universal History*: vol. 1, 7; see Geer 1954).

The environmental context

Egypt is a land of contrasts: most of the country is desert, but in antiquity the annual inundation of the Nile brought down water and silt, which created a triangle of fertile land in the north (the Delta), and a strip of cultivated land on either side of the river. Continuous irrigation and ceaseless vigilance were needed to maintain this scarce agricultural land, which supported the people, and their crops and animals.

From Neolithic times, towns and villages became established here, and because this cultivated area could not be sacrificed for the burial of the dead, the corpses – usually covered by a reed or skin mat – were placed in shallow graves in the nearby desert.

It may have been religious beliefs that first inspired the Egyptians to try to preserve the bodies of the dead in as enduring and lifelike a state as possible, but geographical and environmental factors also played a significant role in the development of mummification.

Natural and artificial mummification

A combination of the hot, dry climate and the location of the shallow graves in porous sand provided conditions that ensured that these bodies were preserved indefinitely. The body fluids of the newly buried corpse evaporated and were absorbed by the sand, a process that arrested decomposition and produced desiccated, practically sterile bodies that could last indefinitely in the right environmental conditions. Such corpses, complete with skin and hair, are excellent examples of 'natural mummification,' and indeed may have been the inspiration for later attempts at artificial preservation.

Although this method of burial continued in use for the poorer classes throughout the historical period (c. 3100–332 B.C.), intentional preservation of the corpse (mummification) was introduced first for the elite burials, and eventually for all who could afford this method.

The reasons for artificial mummification, and the date when it was first introduced in Egypt, cannot yet be confirmed. Until recently, Egyptologists associated this development with a new type of grave built for the kings and wealthier classes in the Archaic Period. Their bodies now rapidly decomposed because they were interred in an underground burial chamber lined with mudbrick or wood, rather than being in direct contact with the sand.

Even at this date, the Egyptians probably believed that preservation of the body was essential to enable the deceased owner's immortal spirit to return to the corpse and use it to derive spiritual sustenance from food offerings regularly placed at the tomb. Thus, Egyptologists have speculated that artificial preservation was possibly introduced now to provide an alternative method of preserving the lifelike form and features of the deceased.

New evidence indicates, however, that features that may be associated with early artificial mummification (i.e., enclosing parts of the corpse in tight-fitting linen wrappings and impregnating this material with resinous substances) were already present in the Badarian Period (c. 4500–4100 B.C.), at Badari and Mostagedda.

Elsewhere, in predynastic cemeteries (Naqada IIa-b) at Hieraconpolis (Davies and Friedman 1998: 206–208) and Adaima (c. 3500 B.C.), some stages of intentional mummification have also been observed (wrapping the body and applying resin to the bandages and to selective areas of the body). This is not, however, conclusive evidence of intentional preservation; it may simply represent aspects of the funerary ritual (Jones 2002: 7).

There is new confirmatory evidence from Abydos that some features associated with intentional mummification were already in use in the earliest dynasties. A photograph taken by Petrie during excavations of the royal tombs at Umm el-Qaab, Abydos, during 1899–1900 (Petrie 1901: vol. 2, 16, pl. ii) shows a wrapped forearm, complete with four bracelets, which was concealed in a hole in the wall of the tomb of King Djer (first Dynasty). This arm may have belonged to his queen. Recent studies have demonstrated that textiles associated with this arm appear to have been impregnated with a substance that may be resin (Jones 2002: 5–6).

Another early attempt at mummification was noted by Quibell in the second Dynasty necropolis at Saqqara (Quibell 1923: 11, 19, 28, 32. Pl.XXIX(3)). The body of a woman had been wrapped in many layers of bandaging, and between the bandages and bones, there was a large mass of very corroded

linen, suggesting that crude natron or some other substance may have been applied to the surface of the body as a preservative.

Natron is a natural deposit that occurs at El-Kab and in a desert valley known today as the Wadi en-Natrun; it consists of sodium carbonate and bicarbonate, and sometimes includes small amounts of sodium chloride and sulphate. When artificial mummification was practised in later periods, natron was used as the main dehydrating agent (Nicholson and Shaw 2002: 383–4).

Even in the Old Kingdom, the evidence for artificial mummification is scant. A mummy discovered by Petrie at Medum (and later presented to the Royal College of Surgeons in London where it was destroyed during an air raid in 1941) probably dates to the fifth Dynasty, and demonstrates that the embalmers had moulded the outer bandages, saturated with resin, to attempt to recreate the body contours and facial features (Petrie 1892: 17–18). In 1913, Reisner's excavations at Giza revealed a similar mummy (Reisner 1913: vol. 11, 58, fig. 9).

Mummification in the Old Kingdom

Generally, the outer appearance of the body was emphasised in mummies of this period: the limbs were separately wrapped in tight-fitting linen bandages, and the facial features, breasts, and genitalia were moulded in a gummy substance with the details added in paint. Although Junker, also working at Giza, found examples in which the head or entire body (covered first with a fine linen cloth) was coated with a layer of stucco-plaster (Junker 1929–1959: vol. 6, 226; vol. 3, 224), and details of the bodily features and the head were carefully depicted.

The end result, however, was still unsatisfactory because underneath the elaborately wrapped and moulded form, the body continued to decompose. A successful method of artificial mummification still had to be found. A major advance was introduced in the early fourth Dynasty: the evisceration of the abdominal and thoracic cavities. This was probably a deliberate and conscious attempt to arrest decomposition, which now replaced earlier efforts to recreate a modelled likeness of the body.

The first definite evidence of evisceration is provided by the contents of Queen Hetepheres' tomb, discovered near the pyramid of her son, Khufu, at Giza (Reisner 1928: vol. 26, 80–81). Although the mummy itself was missing (possibly removed by tomb robbers from the original burial site), this reburial contained packets of viscera that had been treated with natron (Lucas 1962: 271). Thus, the two crucial procedures required for artificial