THE SCIENTIFIC STUDY OF MUMMIES

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Chapter 1. History of mummy studies

Introduction

A book about mummies needs to begin by defining the term "mummy". Historically the term is a misnomer. The English word "mummy" has taken a circuitous course to reach its present meaning. Pursuit of this serpentine path exposes us to several fascinating eras of ancient history. One of these is detailed in Chapter 10 (see Mummy as a drug) but can be summarized here. As early as the first century AD the Roman historian Pliny the Elder (AD 23–78) was lauding the medical virtues of a black, tarry material oozing spontaneously from earth fissures in several locations of what we now call the Middle East. Especially popular was a site in modern Iraq (ancient Persia) near Babylon in the territory of Darábgerd. This material, which we would call asphalt or bitumen, was called *múmiyá* by the Persians (perhaps because its consistency resembled that of wax, called *mûm* by the Arabs) (Pettigrew, 1834:1). When its medical popularity exceeded its supply in about the thirteenth century, the black, crystalline resin found in ancient, mummified Egyptian bodies was substituted for the bitumen, since its gross appearance suggested chemical identity. The term *múmiyá* was then transferred to such resins (Dawson, 1927f). Still later, when the resins' apparent superior clinical efficacy was attributed by European physicians to the desiccated, light-brown muscle fragments often accidentally included within the mummies' resin, the term was again transferred – this time to the preserved nonskeletal (soft) tissues of the human body that were thereafter employed as medical therapeutic agents. When that practice subsided in the eighteenth century the term finally evolved into its present application, referring to any form of mummified human remains.

In adjectival form the term "mummified human" can be applied conveniently to even the smallest nonskeletal fragment of a human body surviving a postmortem interval long enough normally to anticipate complete decay. Few, however, would use the noun "mummy" to designate an isolated fingernail, lock of hair or dry skin fragment. This indicates that, for most people "mummy" induces a mental image of a corpse with soft tissues sufficiently preserved to resemble a once-living person. This is far from the type of precision we normally accept within scientific terminology, but if language is to be an effective communication medium it must conform to popular usage. Hence, this book will employ the term "mummy" in this general sense, modifying it with descriptive adjectives where necessary.

Justification of studies

But why study mummies at all? The tombs of the world's largest and most examined group of mummies in Egypt have contributed much information useful to recovery of Egyptian views of life and the afterworld through study of inscriptions on the tomb walls, on the mummy's container (cartonnage, coffin or sarcophagus) or on linen wrappings and included papyrus scrolls. The principal focus of interest on the body itself, however, has been the documentation of specific features of the mummification process. These would then be used to establish a chronological sequence of mummification features that can be used for dating purposes in much the same way that the form, composition, and decoration of ceramic features are commonly employed in archaeology. Even the evidence of disease occurring in Egyptian mummies has been derived largely on the basis of simple gross observations of skeletal and some soft tissue malformations, commonly published as isolated cases or simply as addenda to archaeological reports.

The above only hint at the vast residue of latent information that is resident in both the soft and skeletal tissues in these bodies. But how available is this information, and what needs to be done to obtain it? Some of the answers to these questions were provided at several pioneering seminars by the University of Manchester, England (David, 1979, 1986), the mummy dissections by members of the Paleopathology Club and the Paleopathology Association, and especially in the 151 manuscripts read at the First World Congress on Mummy Studies held in Puerto de la Cruz on Tenerife in the Canary Islands on February 3–6, 1992 (Archaeological and Ethnographical Museum of Tenerife, 1995). The more than 300 scientists gathered at that Congress described the application of a broad range of biochemical, biophysical, radiographical, radiometric, photo-imaging, molecular biological and other techniques to spontaneously ("naturally") and anthropogenically ("artificially") preserved human remains from sites on nearly every continent. The wealth of new data presented at that meeting represents a quantum leap forward in the study of ancient populations. Above all, it brought into focus the existence of the enormous legacy of biomedical and sociocultural information present in mummified human remains. Even extant technology is capable of extracting a significant fraction of it. Such recovered information can be integrated with the existing biomedical and bioarchaeological database; these data are unique because they can not be acquired by other means.

This is the very definition of a new branch of science. Because science is the pursuit of truth, it is its own justification. The term *science* is used here to include all forms of scholarly endeavor including, but not limited to, history, archaeology, anthropology, ethnology, art, biology, museology and medicine. The purpose of this book is to document the field's current database as well as identification of the nature and potential of methods employable to expand it.

Ethical aspects of mummy studies

A growing world-wide movement emphasizing ethnic identity is affecting the study of human remains. In some areas ethnoconsciousness is so powerful that it overrides nationalistic concerns. The roots of these forces are so deep and complex they may be unknowable in their entirety. They surely, however, include such factors as disappointment over the failure of both science and many experimental forms of population governance systems to solve basic social problems. They also involve the perception of anonymity of population subgroups in increasingly densely populated areas, and the extension of communication systems that permit the people of even the remotest part of our planet to be aware of conditions elsewhere. The effect of these and other contributing factors is a search for identity and socioeconomic solutions among population subgroups sharing common cultural heritage practices and world views as well as language, and, in some cases, religious hallmarks of ethnic identity. Ironically, this process of shrinking one's sociocultural space coincides with the increasing awareness by large nation states of their global interactions and interdependence.

This process has had a profound impact on the study of antiquity through examination of human remains. One aspect of the several, different responses to these changes has been increasing interest in one's ancestral origins, and is reflected not only in a flurry of related publications (Haley, 1976) but also in grass roots efforts to recover the features of the life of aboriginal populations (Tenerife's 1990 Cronos Project, others). Simultaneously such growing identification with ancestors has also extended to their physical remains in many areas, leading to restriction of their exhumation and study by dissection or other methods that are viewed as offensive and irreverent. Australia, USA, Israel and other countries have regulated such practices, and increasing minority militancy is making similar demands in parts of South America, the Canadian Arctic and elsewhere. Understanding of such ethical concerns is imperative for the success of a scientist involved in mummy studies.

Because it is within this global climate that we must carry out our work, ethical concerns need to be dominant in the minds of scientists involved in the dissection or sampling of mummified human remains. Investigators of mummy studies will be most comfortable in subsequent work if they first evaluate their own views by any criteria or features perceived to be relevant and arrive at a comfortable conviction. It may be necessary to participate in one or more dissections to achieve the experience necessary to make this informed decision. The next, equally important step is the recognition that all others concerned with a possible mummy dissection have an equal right to reach other, but equally valid, viewpoints. In the perfect world those influencing the decisions regarding the extent of dissection (museum board, institutional administrators, legislators, etc.) would make the same effort to be as informed as possible when making such judgments. Since this seldom occurs spontaneously, it is in the investigator's interest to prepare such a report or oral presentation. In such circumstances, a highly *persuasive* stance by the investigator is rarely successful. Usually more useful is a presentation identifying the nature of the proposed study, the types and value of information expected to be gained and possible alternative limitations of the extent or modifications of the dissection. Risks, inconveniences or costs as well as possible museum applications of the data generated need to be pointed out. Optimally, all this can be carried out in a manner transmitting the investigator's recognition of normal concerns about dissection and respect for the ultimate decision. Once the decision has been made, all concerned with the examination must honor whatever restrictions are imposed without manifesting judgment.

The degree of survivors' identification with the physical bodies of deceased relatives varies enormously both between and within cultural groups. I have encountered the full range of concerns about the extent of dissection, varying from total indifference to complete prohibition. Furthermore, if the decision-makers can be fully informed, the degree of dissection limitation is not necessarily correlated with emotional concerns for the remains. In one such study in which I participated, the controlling group's members' sincere and deepest reverence for the remains was obvious, yet after becoming fully informed they imposed as their only restriction the prohibition of public display and the prompt return of the remains after study completion.

This situation is not very apt to change in the near future. Hopefully the information in this book will help both scientists and those controlling access to mummified human remains to reach a level of understanding that will permit both to be comfortable with such studies. Human behavior is best understood when it is studied in the context in which it occurred. It seems appropriate, therefore, that we begin our process of understanding this new scientific discipline by reviewing its history.

The Archaic Period

The study of mummified human remains is an outgrowth of the study of the bodies of recently deceased humans. Not surprisingly, then, the history of human mummy dissections is an inseparable part of the pursuit of human anatomical knowledge. We can begin our review, therefore, with Preceramic hunter–gatherer groups. Certainly, early hunting groups dissected their prey both as part of the butchering process

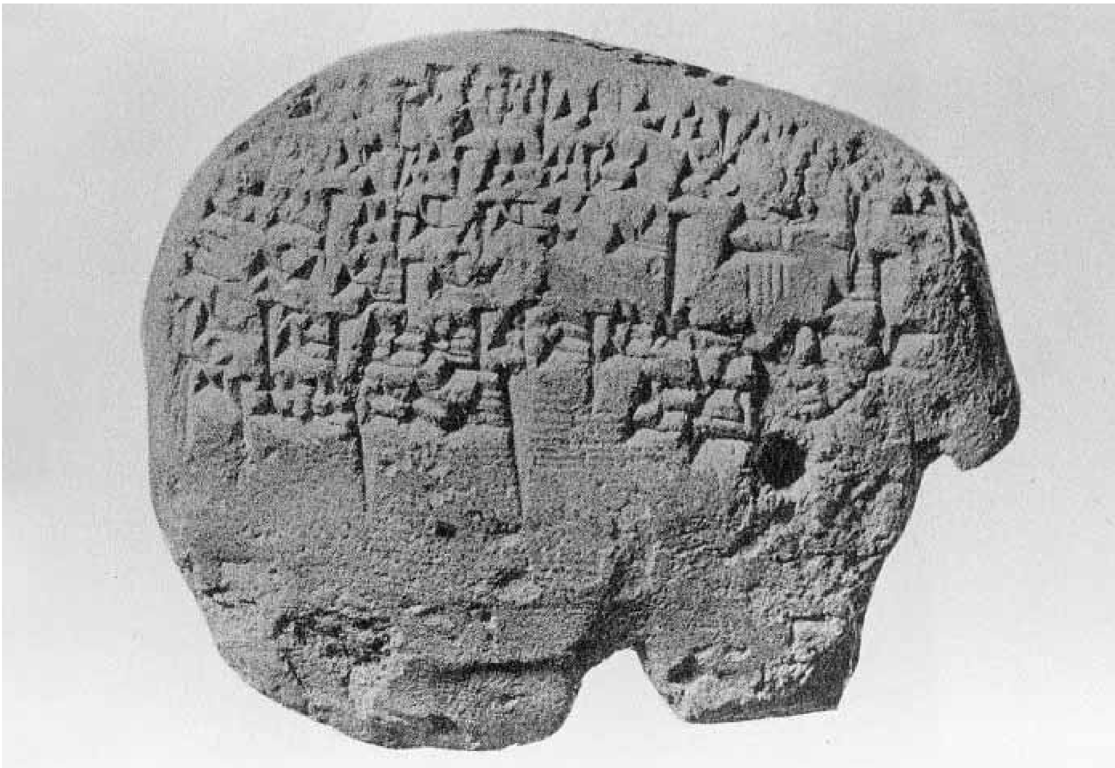

Fig. 1.1. Clay model of sheep liver.
Cuneiform inscriptions on this clay model of a sheep liver suggest its employment for divination purposes. (Courtesy of author Albrecht Goetze, 1947: Plate CXXXIV, and Yale University Press (copyright).)

and also for magicoreligious purposes such as sacrifice or divination. One might anticipate that, by opening animal or human bodies, these early populations would have gained anatomical knowledge from such rituals. Archaeological findings at Mesopotamian sites have uncovered clay models of animal livers that presumably were employed as instructional devices to teach neophyte clerics the interpretation of changes useful for the translation of divine messages (Goetze, 1947; Mujais, 1999) (Fig. 1.1). A comparable bronze model of a sheep's liver with inscribed subdivisions found in Italy apparently served a similar divination purpose for Etruscans (Lyons & Petricelli, 1987:67, 232). Both ethnographical and archaeological data indicate that examination of intestines extracted from human sacrifice probably was based on a similar divination principle (haruspicy) among Pre-Hispanic Peruvian populations (Allison *et al.*, 1974c). Guides to the Hebrew practice of examination of animals and meat in the Babylonian Talmud of the second century AD include reference to several specific visceral structures (Garrison, 1929). However, as Ackerknecht (1943) points out, there is no evidence that any such dissections led to an understanding of detailed human anatomy, the functional interaction of various body tissues or any other useful anatomical information beyond that needed to satisfy the requirements for the ritual purposes of such dissections. Benedict (1934) has established a theoretical basis for support of a concept that "only in the context of a culture pattern oriented towards a kind of 'science' do dissections furnish anatomical knowledge . . .".

Classical Greek and Roman periods

Flickers of the beginning of such a scientific movement about 500 BC can be read into the animal dissections carried out by the southern Italian physician Alcmaeon of Crotona. In his book *Concerning Nature* detailing his dissections, Alcmaeon made it clear that his goal was a better understanding of human anatomy that would be helpful in his medical practice. Lyons & Petrucelli (1987:192, 399) consider him to be the first medical scientist, and note also that a subsequent Hippocratic publication about shoulder anatomy most likely was the product of a human dissection. The intellectualism of classical Greece, however, did not include human dissection. Thus it is not surprising that the commitment to a search for truth that formed the basis for the existence of the Alexandrian museum and library would lead men such as Herophilus of Chalcedon and Eristratus of Chios to base their learning of human anatomy on human dissections there during the third century BC. Tragically, the prohibition of human dissection by Rome in 150 BC arrested this progress and few of their findings survived. By the second century AD, Galen, the Greek physician who practiced principally in Rome, popularized the humoral theory of health and disease with the aid of only two human skeletons and animal dissections but without laboratory-based opportunities for human soft (nonskeletal) tissue dissection to guide him (Long, 1965:9–11; Lyons & Petrucelli, 1987:399; Porter, 1996:60).

Fig. 1.2. The medieval teaching of Galenic concepts. This fourteenth century painting pictures Galen as a feudal lord surrounded by his courtiers, reflecting the dominance of his anatomical and medical ideas during the Dark Ages. (Courtesy of Masters and Fellows of Trinity College Cambridge (Trinity MS 0.2.48, f.65a). Porter, 1996: 64.)

The Dark Ages

Rome's fall initiated the Dark Ages, during which Galenic concepts were perpetuated but not tested (Fig. 1.2). While during this period the Church did not forbid human dissections in general, certain edicts were directed at specific practices. These included the *Ecclesia Abhorret a Sanguine* in 1163 by the Council of Tours and Pope Boniface VIII's command to terminate the practice of dismemberment of slain crusaders' bodies and boiling the parts to enable defleshing for return of their bones. Such proclamations were commonly misinterpreted as a ban on all dissection of either living persons or cadavers (Rogers & Waldron, 1986), and progress in anatomical knowledge by human dissection did not thrive in that intellectual climate.

The Renaissance

The sweeping changes of the Renaissance involved not only the arts but also the sciences, including the construction of European universities. The revival of

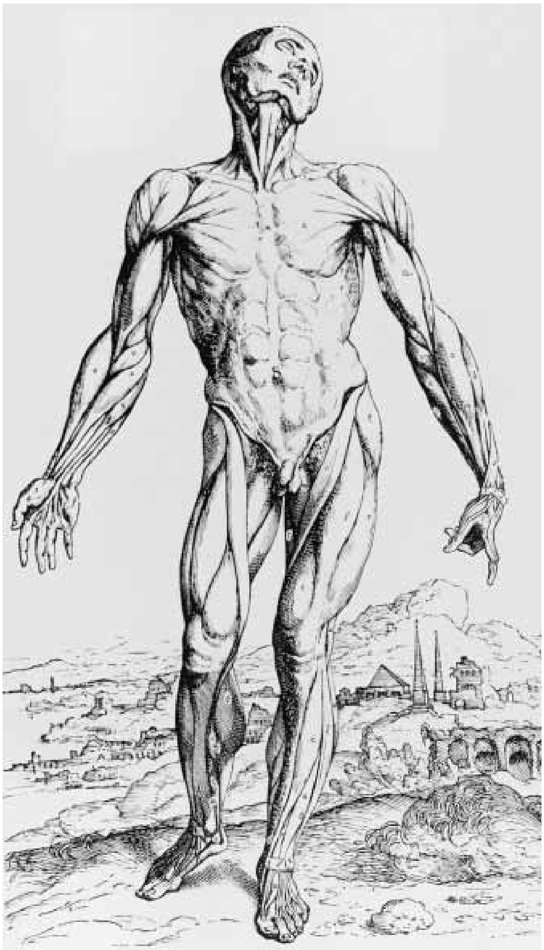

Fig. 1.3. Reproduction of an illustration from the sixteenth century anatomy text published by Andreas Vesalius.
Vesalius' 1543 text dethroned Galen by establishing that the ultimate authority of anatomical knowledge was the anatomical features of the human body itself as revealed by dissection. (From illustration Primae Muscolorum Tabulae, p. 170 of his 1543 book titled *De Humani Corporis Fabrica Libri Septem.* Published by Johannes Oporinus, Basel. Courtesy of New York Academy of Medicine Library.)

human dissection became part of this movement. Soon, however, dissections were performed for reasons much more proximate to those characterizing modern mummy dissections. The aim of this practice gradually shifted from expanding knowledge of normal anatomy to the understanding of disease through study of pathological anatomy. One of the earliest postmortem dissections carried out for the specific purpose of identifying the cause and mechanism of death was the autopsy of a plague victim by Fra Salimbene di Adam at an Italian monastery in Cremona in 1286 (Rogers & Waldron, 1986). It was, however, the newly established universities at Bologna and Padua that pioneered the routine performance of autopsies. In 1302 Bartolome da Varignana carried out medicolegal autopsies at Bologna, while Gentile da Foligno held regular public human dissections at Padua University by 1341. This practice proved so popular that it was imitated and institutionalized by most major universities during the subsequent century (Garrison, 1929). It was the Padua graduate Andreas Vesalius (1514–1564) (Fig. 1.3) who maximized this trend, organized his dissections in a focused manner and challenged the many anatomical errors of Galenic anatomy when he published his richly illustrated book, *De Humani Corporis Fabrica* in 1543 (Lyons & Petrucelli, 1987:416). Thereafter it became clear that the final arbiter of an anatomical controversy would not be the opinion of a well-known physician but the body itself as revealed by dissection. Many hours of observing human dissections carried out by anatomists enabled Michelangelo to paint the muscled physiognomy of the Sistine Chapel's figures, while Leonardo da Vinci's numerous personally conducted dissections of human bodies helped him to execute his dramatic anatomical illustrations (Yesko, 1940) (Fig. 1.4). All of these dissections, coupled to close observations in living humans and animals led to the revolutionary definition of the circulation of blood in William Harvey's 1628 *Exercitatio anatomica de Motu Cordis et Sanguinis in Animalibus* (Porter, 1996:159).

Scientific rustlings in the eighteenth century

With human anatomy now firmly rooted in human dissections, interest became increasingly focused on pathological anatomy: the morphological changes

Fig. 1.4. Da Vinci anatomical sketch.
This pencil drawing by Leonardo da Vinci was clearly a sketch of a human anatomical dissection. (Photo courtesy of The Royal Collection © 2001, Her Majesty Queen Elizabeth II.)

caused by various diseases. Men such as Nicolaes Tulp, a practicing Amsterdam physician, taught anatomy by human cadaver dissection in the Dutch medical schools and both described and illustrated many pathological entities that he encountered in such dissections in a 1641 text entitled *Observationes Medicae* (Fig. 1.5). Compilations of autopsy reports for teaching purposes began to appear in the latter part of the seventeenth century and early eighteenth century, culminating eventually in the 1761 publication of the five-volume *De Sedibus et Causis Morborum* [Seats and Causes of Disease] by Battista Morgagni (1682–1771). As great as that contribution was, it was soon eclipsed by events in Vienna. There the Austrian emperor Joseph II, son of Maria Teresa, in 1784 rebuilt the Allgemeine Krankenhaus [General Hospital] into a 1600 bed hospital to serve the health of the poor (Porter, 1996:212) (Fig. 1.6). The eventual decision to autopsy all deaths at that hospital had an enormous impact on human dissection everywhere in the Western world, together with stimulating an immense increase in knowledge about both normal and pathological human anatomy (Long, 1965:102–105).

Surely there were occasional examinations carried out on mummified human bodies during the eighteenth century, most of which probably went unrecorded. Several that we know about include the opening of several Egyptian mummy bundles by Blumenbach (1794), some of which proved to be frauds (see Chapter 10: Mummy as deceptions). Granville (1825) lists a variety of sporadic studies dating back as far as 1662. Few of these, however, were significantly informative. One such study of the mummification method performed on an Egyptian mummy was documented by John Hadley (Dr William Hunter was a participant as well) as early as 1763. In a letter to a friend, Hadley lists his findings but notes that they probably differ little from those of others who had done similar examinations (Hadley, 1764).

The autopsy in the nineteenth century

It was Karl Rokitansky who took over leadership of the pathology department at Vienna's Allgemeine Krankenhaus in 1832 and turned it into an autopsy machine. In addition to all the cases other members of his staff performed, Rokitansky personally carried out or immediately supervised about 30000 autopsies during the subsequent 30 years, and created what is still the world's largest museum of pathological lesions (Long, 1965:102–106; Malkin, 1993:114). This emphasis on the value of autopsies was still in practice in 1947 when I had the privilege of studying pathology there briefly under Dr Hermann Chiari. The information generated by these autopsies (much of it included in Rokitansky's five volume *Handbook of Pathological Anatomy*) catapulted Vienna into the position of being

Fig. 1.5. ***A Lesson in Anatomy*****.**
Rembrandt painted Nicolaes Tulp (1593–1674) of Amsterdam, demonstrating anatomical features by actual dissection of a human cadaver in 1632. (Courtesy of Stichting Vrienden van Het Mauritshuis, den Haag [Royal Cabinet of Paintings, Mauritshuis, The Hague, NL].)

the major medical teaching center of the Western world. Within a few decades, however, medical leadership passed into German hands. Berlin's Rudolf Virchow, also using both the autopsy and surgical specimens, shattered Rokitansky's adherence to remnants of Galen's humoral physiology by eventually placing pathological anatomy and the understanding of human disease on the firm basis of cellular pathology, where it remains today.

The serpentine path of the development of biomedical knowledge that had been initiated in the darkness of human sacrifice was subsequently enlightened by anatomical dissections and finally burst into efflorescence with the autopsy. These established methods, so effective in generating knowledge of contemporary disease, were now ready to be applied to ancient mummified remains in an effort to understand modern disease even better by linking it to its prehistory.

Mummy dissections in the nineteenth century

Oddly, it was a military commander, Napoleon Bonaparte, who indirectly created the milieu that led to mummy studies. In a precedent-setting action Napoleon carried about a hundred scientists (from

Fig. 1.6: Vienna's Allgemeine Krankenhaus (General Hospital).
Rebuilt by Joseph II in 1784, the pathological anatomical knowledge acquired by this hospital's autopsy program propelled Vienna into world medical leadership. (Courtesy of Historiches Museum der Stadt Wien.)

what formerly had been called the French Academy of Sciences and was so renamed a few years later) with his army that invaded Egypt in 1798. These scientists were charged with drawing and recording all aspects of Egyptian society, technology and natural history. During the next two decades they published their findings in nineteen volumes (*Description de l'Égypte*), filled with fascinating hieroglyph-covered monuments, tombs, portraits and even mummies (though no dissections were performed) (Denon, 1821:219–220). These enchanting folios, together with the cracking of the hieroglyphic code by Young (Peacock, 1855) and Champollion (Davies, 1987:47–68) in 1819–1822, are principally responsible for the wave of Egyptomania that swept the Western world and generated intense interest in all aspects of Egyptian culture, including their mummies.

In such an atmosphere it was almost inevitable that hucksters would exploit the opportunity. Extracting the bodies of Egyptian mummies from European pharmacies (leftovers from the earlier days of the production of medicinal mummy powder – see Chapter 10: Mummy as a drug) or importing them directly from Egypt, these promoters carried out pseudoscientific mummy "unrollings" for paying public admissions. These were little more than entrepreneurial spectacles. Eventually, however, they evolved into serious, educational studies. As early as 1833 the Egyptologist John Davidson (cited in Sluglett, 1980) formally reported his study and findings of *Embalming and Unrolling of a Mummy*. Among others who rescued mummy studies from the frauds was Dr Thomas Pettigrew F.R.S., professor of anatomy at Charing Cross Hospital in London (Fig. 1.7). His first

Fig. 1.7. Thomas Pettigrew.
A British pioneer of mummy investigations, this physician's 1834 book (A *History of Egyptian Mummies*) was among the first to emphasize the bioanthropological information that was resident in ancient mummified remains. (From Dawson, 1934. Drawing by Charles Baugniet. Courtesy of the Egypt Exploration Society.)

unrolling of an Egyptian mummy at that hospital in 1833 was attended by many physicians as well as a few nonmedical dignitaries. During the next 18 years he examined 13 more. He established public courses of six meetings' length, in which the first five were lectures of two to three hours each on a wide variety of Egyptological aspects, the final one devoted to the unrolling of a mummy. Pettigrew did charge fees, but at that time it was standard practice for professors to charge students fees for each lecture as this was their only remuneration; they were not paid by the institution. These courses were obviously of a high quality and designed for educational purposes (Dawson, 1934). His 1834 book (A History of Egyptian Mummies) includes much of the information incorporated into such lectures and, in spite of its title, does include consideration of non-Egyptian mummies as well, such as the Canary Islands Guanches, Palermo's Capuchin monks, etc.

Another popular nineteenth century academic passion was craniometric analysis designed to differentiate the human races. In an attempt to identify the native Egyptian population's founders, such studies were also carried out early on, notably by the American anthropologist Samuel George Morton in 1844 (he is also author of *Crania Americana* published in 1839). Influenced by the reigning concept that all the world's populations were Noah's descendants, he concluded that Egyptians were Caucasian, of the branch of Ham. Among the more medically oriented studies was the dissection of an Egyptian mummy that had been purchased in Egypt, and investigated by the well-known British gynecological surgeon Augustus Bozzi Granville in 1825. His report includes a drawing (Fig. 1.8) of a large, cystic ovarian tumor he found in the mummy's abdomen (Granville, 1825). A Viennese laryngologist, Johann Czermak, carried out what probably represents the first published microscopic examination of Egyptian mummy tissues in 1852. At about this same time Samuel Birch (1850) reported on his observations of a mummy from Egypt's Late Period. In Canada, Daniel Wilson (1865) compared prehistoric American mortuary practices with those in Europe in a treatise designed to emphasize that human progress was not biologically defined for any given population but depended, instead, on environment and social learning. He described his findings when he unwrapped (but did not dissect) several spontaneously mummified bodies from the Atacama Desert near the modern city of Arica that is now in Chile but was at that time in Peru (Berger, 1990). In 1892 Germany's R.W. Schufeldt described the scientific value of studying ancient human remains and introduced the term

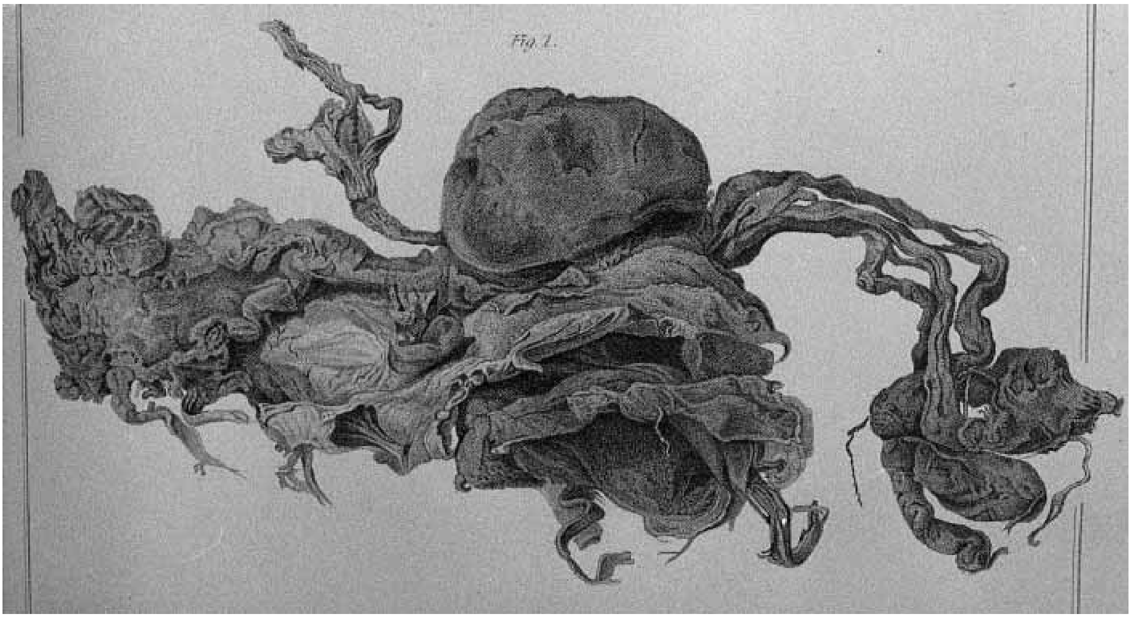

Fig. 1.8. Ovarian cyst in a mummy; AM, 1549–1069 BC.
Granville (1825) found this desiccated, large ovarian cyst in an Egyptian mummy. (Reproduced from *Philosophical Transactions of the Royal Society of London*.)

paleopathology to define the field. This period also was marked by the founding of the United States Army Medical Museum (Fig. 1.9), stimulated by the desire to understand better and improve results of limb amputation for gunshot wound injuries and other military health concerns during the American Civil War. The later collections of this institution (now the National Museum of Health and Medicine) have made major contributions to the study of mummified tissues of globally distributed provenience (Sledzik & Ousley, 1991).

In an obscure pamphlet, W. Koenig (1896) published an X-ray of an Egyptian mummy bundle of a cat about a year after Roentgen announced his discovery of X-rays (Fig. 1.10).

These scattered, uncoordinated and largely unfocused efforts reflect the beginnings of studies on mummified human remains, at least some of which, like Granville's dissection, represent application of the autopsy approach developed in the previous era as a method of obtaining medically useful information.

The twentieth century

Egyptomania of the first quarter

This is a remarkably productive period for study of mummified remains. The period began with a dermato-histological study on mummy skin (Wilder, 1904), followed by a pioneer effort by Grafton Elliot Smith applying to mummies the newly discovered technique using X-rays (see Chapter 6: Physical methods: radiographical methods), and a survey on brain mummification (Lamb, 1901). In addition, in Germany, Schmidt (1908) tried to find hemoglobin by using chemical tests on Egyptian mummy tissue. Lucas (1908) initiated the chemical studies that later became his principal contribution to Egyptology by identifying and quantifying the various salts that compose natron, the Egyptian embalmers' dehydrating agent. Shattock (1909) reported finding calcified atherosclerosis in Pharaoh Menephtah's aorta. In Munich, Meyer extracted human mummified muscle tissue, injected it into

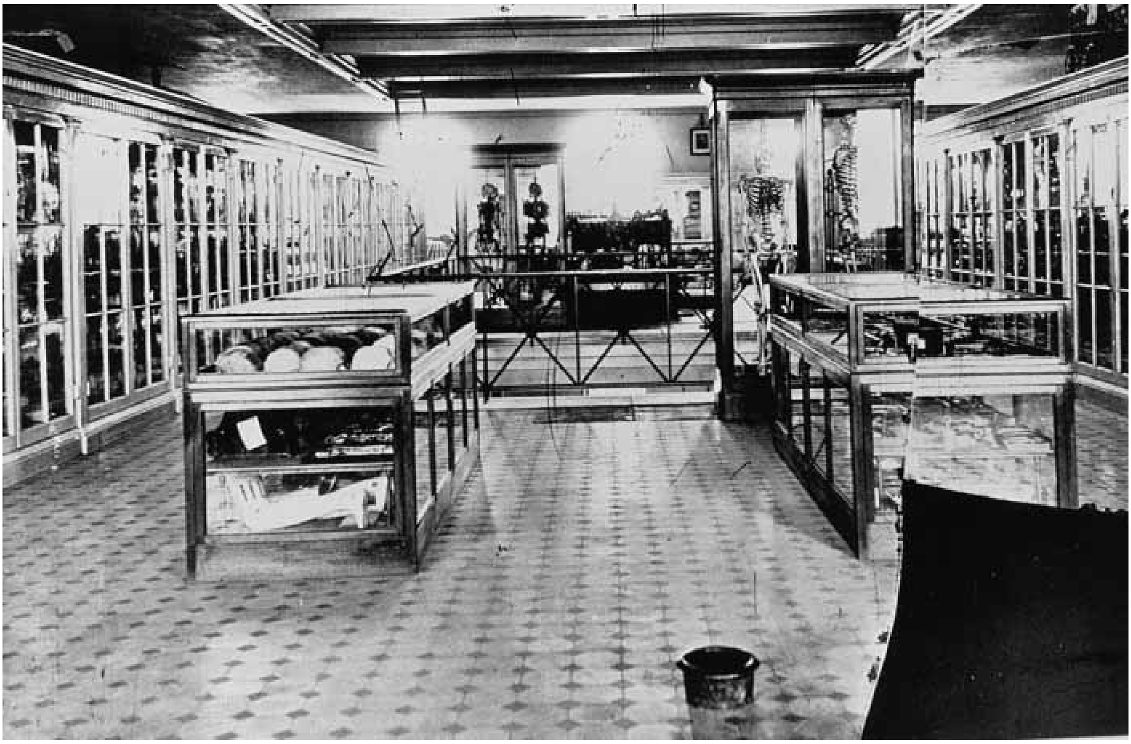

Fig. 1.9. US Army Medical Museum.
This photo of the museum reveals its appearance when it was located for eight years beginning 1967 in what is now Ford's Theatre in downtown Washington, DC. It was later transferred to the campus of the Armed Forces Institute of Pathology and is now called the National Museum of Health and Medicine. (Courtesy of Paul Sledzik.)

rabbits and used an immunological precipitin technique in an effort to develop a test for human blood identification (Meyer, 1904). But it was Marc Armand Ruffer (1859–1917) who provided the major impetus. Born in Lyons, France, of aristocratic parents he was educated at Oxford, gained a medical degree at University College London and became a clinical bacteriologist at the Pasteur Institute in Paris under its founder. While there, Ruffer came under the influence of the French physician Daniel Fouquet, who had become interested in the medical potential of studying diseases in mummies. Fouquet had traveled to Egypt and carried out an autopsy on a 1000-year-old mummy in the Cairo Museum in 1891 (Fouquet, 1897). Suffering from paralytic sequelae of diphtheria (acquired during study of a vaccine's effectiveness) Ruffer moved to Egypt to recuperate. There he became professor of bacteriology at the Cairo Medical School in 1896. Extensive excavations in Nubia (salvage archaeology in anticipation of flooding resulting from raising the Aswan Dam in 1907) by the American archaeologist George Andrew Reisner made prodigious numbers of mummies available for study. Ruffer joined Grafton Elliot Smith (Australian anatomist), F. Wood Jones, Douglas Derry and others in the investigations carried out on these bodies. Although Ruffer (1911b) employed both gross and histological methods, he is best remembered for his microscopic contributions. A flow of reports (some published posthumously) in scientific journals between 1910 and 1921 record his findings in these Nubian and Egyptian mummies. Many of the diseases that he identified in

Fig. 1.10. Early X-ray of Egyptian cat mummy bundle. W. Koenig (1896) published this photo of an X-ray of an unwrapped small Egyptian mummy bundle revealing a mummified cat only about a year after Roentgen had discovered the existence of X-rays.

these mummies reflect his training in infectious diseases: schistosomiasis (Ruffer, 1920), abscesses, tuberculosis, pyorrhea (Ruffer, 1921a) and splenomegaly (malaria?), but he also recognized atherosclerosis (Ruffer, 1911b), achondroplasia and rectal prolapse, as well as a host of skeletal and dental pathological conditions (Ruffer, 1913). Ruffer's career was terminated tragically when the ship on which he was returning from a Red Cross consultation in Greece was torpedoed and sank in 1917 (Garrison, 1917). His American friend and colleague Roy Moodie collected his scattered reports and published them under Ruffer's name in book form in 1921: *Studies in the Paleopathology of Egypt*.

Grafton Elliot Smith (1887–1937) was an Australian neuroanatomist with an appointment at Cambridge University who accepted a faculty position at the Cairo Medical School 1900–1909. His skills were quickly recruited to evaluate the many skeletons and mummies that the archaeologists were excavating. Beginning with the examination of a series of mummies ranging from the Old Kingdom to the Coptic Period (*The Ancient Egyptians*, 1911a) he responded to an invitation to study all the recovered mummified bodies of the pharaohs (*The Royal Mummies*, 1912b). During those investigations he used Roentgen's newly discovered X-rays to estimate the individual's age at death by the degree of epiphyseal fusion in the mummy of Tuthmosis IV. The Egyptologist W.M.F. Petrie was among the first to use X-rays to study a human mummy in 1897 (but published in 1898), within two years after Roentgen's scientific presentation of his discovery in December, 1895. Perhaps his largest project involved the examination of Reisner's Nubian mummies (Reisner, 1910), a study carried out with F. Wood Jones (Smith, 1910).

Smith probably dissected more Egyptian mummies than any other worker had done before (and perhaps even since) his time. It is unfortunate, therefore, that we do not have the detailed record of each dissection. Together with mummies excavated by other archaeologists, Dawson (1938) estimates that Grafton Elliot Smith was responsible for the examination of 30 000 mummies (obviously a number prohibitive of detailed dissection and recording of findings (Dawson, 1938). This number is rivalled only by the efforts of Rokitansky, who achieved it with hospital autopsies at Vienna's Allgemeine Krankenhaus over a longer period (30 years), with the help of his staff and with few conflicting other duties (Malkin, 1993:114). Instead, we are left primarily with Smith's summary statements as recorded in the books noted above, as well as a variety of individual articles. Sadly, these do not permit re-examination nor restudy with the synthesis of new conclusions. We need, however, to consider the enormous volume of mummies Smith examined while he carried out his other responsibilities and activities simultaneously (medical teaching, continuing his personal neuroanatomical research, buttressing his anthropological knowledge with self-study, lecturing unceasingly at international meetings and publishing a continual flow of articles and books). Hence we probably should be more grateful for, than critical of, what he has left us. Unfortunately he evolved a highly improbable concept of the global diffusion of mummification practice that originated in Egypt. He proposed that such practices spread throughout the world via marine travel by ancient populations indulging in mummification rituals (*The Migrations of Early Culture*, 1915). Defense of this concept, that was supported by only the most fragile evidence, occupied much of his later years and eroded some of his scientific credibility among his contemporaries.

The scholar pursuing the history of mummy studies inevitably will encounter Warren R. Dawson (Fig. 1.11). Born in Ealing (London) in 1888, the death of his father when Dawson was 15 years old terminated his education. Minor posts in the insurance industry eventually led him to create his own agency. The acquisition of a partner resulted in time available for self-education. Wallis Budge, Keeper of Egyptian antiquities of the British Museum, responded to Dawson's thirst for knowledge. In 1914 (at age 30) Dawson studied hieroglyph interpretation. Much of the remainder of his subsequent life became devoted to translations of papyri. These brought him into contact with renowned scientists. By cataloging their collections and publications he received fellowship appointments in the Medical Society of London, the Linnaean Society, Imperial College London and the Royal Society of Edinburgh. He became particularly interested and knowledgeable in methods of Egyptian mummification and medical practice in Egypt. He persuaded Grafton Elliot Smith to write *Egyptian Mummies* (Smith & Dawson, 1924). Though he is listed as a co-author, Dawson himself actually wrote that entire book except for the last two chapters. He made several other major contributions, and when he died in 1968 this unlettered, self-taught, amateur anthropologist left a profoundly impressive quantum of scholarly publications behind him for which the field of Egyptology and mummy studies has been exceedingly grateful (James, 1969).

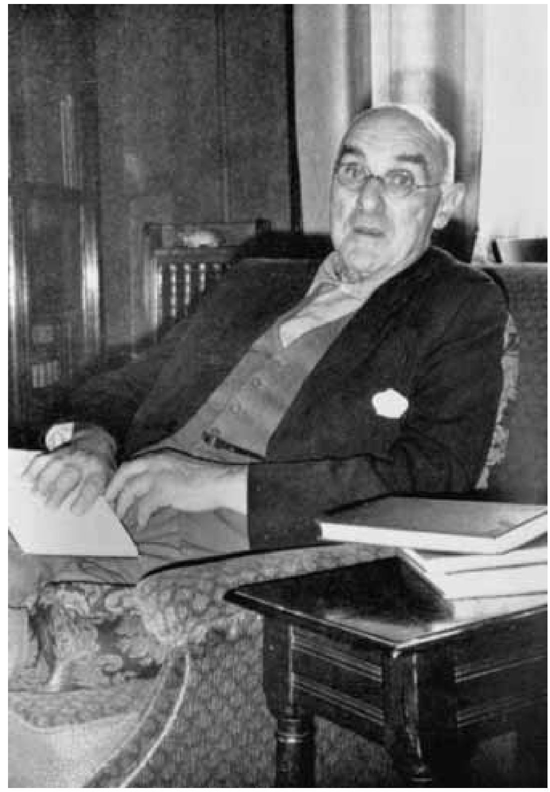

Fig. 1.11: Warren Royal Dawson.
This British insurance agent-turned scholar translated many papyri, coauthored articles with Grafton Elliot Smith and recorded biographies of many early egyptologists. (Biography by James, 1969. Photo courtesy of Egypt Exploration Society.)

Another major figure in the history of mummy studies during this period was Alfred Lucas (1867–1945). Among the physical sciences, chemistry was developing as rapidly as was bacteriology in the biological sciences. Lucas was a British chemist in Egypt's Department of Survey and, after 1923, served in the Department of Antiquities there. His friend and colleague John Wilson (1964:224) describes him as highly informed in forensic chemistry including poisons and even ballistics and handwriting. Lucas' 1926 tome (*Ancient Egyptian Materials and Industries*)

Fig. 1.12. Margaret Murray and associates.
Murray and six colleagues studied two of the Manchester Museum's Egyptian mummy collection in 1910. (Courtesy of Dr Rosalie David and the Manchester Museum, Manchester, England.)

is filled with his chemical analytical applications to materials encountered in Egyptian mummies, with an entire chapter devoted to substances employed by ancient Egyptian embalmers, including resins, Dead Sea bitumen, natron, beeswax, spices, oils, gum, henna, ointments, onions, palm wine, salt, sawdust, fats, minerals and a host of packing materials. The meticulous care he employed in his analyses and his conservative interpretations of analytical results, coupled to his knowledge of the ancient literature dealing with these substances, are constant features of his discussions. They are particularly prominent in his review of analyses relating to the possible use of Dead Sea bitumen as a substitute for resins in mummies. He was preparing for retirement when Carter found Tutankhamun's tomb in 1922, whereupon he offered his services and made valuable contributions to studies of that tomb's materials. His 1926 text was so thorough that it was reprinted in 1962 with additions and deletions by J.R. Harris. This edition remains highly useful today.

Contemporary with the early work in Egypt by Ruffer was the initiation of what would eventually evolve as an eminent research program at the Manchester Museum. This museum curates a major collection of Egyptian mummies and Margaret Murray at that institution began a study of two Egyptian mummies from a single tomb. It was unique in that the examination was interdisciplinary, involving the curator (Murray), a physician (John Cameron), three chemists (Paul Haas, H.B. Dixon, E. Linder) and two textile specialists (Thomas Fox, Julius Huebner) (Fig. 1.12). While soft tissue preservation proved to be less than desirable when the wrappings were removed, a remarkable amount of information was generated by the study (Murray, 1910). The next significant step in the evolution of that program took place in the 1970s (see below).

Finally, the discovery of the now well-known mummies of the Chinchorro people on the coast of northern Chile by the German archaeologist Max Uhle (1917) needs to be noted, even though the bulk of the studies on this group was carried out many years later (see Chapter 4: Mummies from Chile).

The irresolution of the second quarter

Oddly, the auspicious momentum generated in the field of mummy studies in the previous period by such pioneers as Ruffer, Smith and other colleagues was not maintained during the second quarter of the twentieth century. Smith died in 1937, devoting much of his final decade to defending his theory of the spread of mummification out of Egypt. Flinders Petrie transferred the British School of Archaeology out of Egypt to Palestine. The failing eyesight of Harvard's George Reisner (Fig. 1.13) restricted his field activities long before he died in 1942, and Herbert Winlock of the New York Metropolitan Museum of Art left the field to become its director in 1932 (Wilson, 1964). Termination of field work in Egypt by these giants of Egyptian archaeology was paralleled by a decrease in the scientific study of mummies. Although Ehrenberg (1927) published a thoughtful article justifying the place of paleobiology among the general biological sciences, his optimism was not realized during the two and a half decades following 1925. The exuberant 1920s were soon eclipsed by the economic depression of the 1930s, and these were succeeded immediately by World War II, which dominated the 1940s. The social, economic and military instability of this period was not conducive to expansion of the academic field of mummy studies.

Nevertheless, a few, substantive contributions from this period merit citation. Warren Dawson published "Making a mummy" in 1927, and his valuable "Bibliography of works relating to mummification in Egypt", appeared in 1929. The American pathologist H.U.Williams (1927) dissected several Peruvian mummies early in this period, identifying, among other conditions, a calcified thrombus in a leg artery. Boyd & Boyd initiated their serological studies for blood typing on mummy tissues in 1934. In Germany, Graf (1949) extracted a bioactive substance from Egyptian mummified muscle whose action suggested it was probably histamine. While the indefatigable Roy Moodie poured many dozens of publications into the literature before 1931, most of them deal with skeletal pathology (Moodie, 1923). A notable exception is his 1931 landmark radiographical study of the large mummy collection at Chicago's Field Museum (Moodie, 1931). He found a number of them were frauds whose external, wrapped, anthropoid shapes suggested that they contained children's bodies, but whose X-rays indicated that their content consisted only of an adult human leg, animal bones or sticks.

Fig. 1.13. Egyptologist George Reisner. One of the well-known excavators of the late nineteenth and early twentieth centuries, he established collections for Harvard and the Boston Museum of Fine Arts. (Photo courtesy of John Larson and the University of Chicago's Oriental Institute. Photo by Leslie Thomson, Nov. 1935. Negative no. P30077/N. 16329.)

Shaw (1938) reported a detailed microscopic study of the mummified tissues of the Egyptian mummy Harmose. Julio Tello, a Peruvian archaeologist, excavated many spontaneously mummified bodies during this period, but was especially interested in the *Treponema*-like skeletal changes (Tello, 1943). It was also during the late 1920s and 1930s that Ales Hrdlička of the Smithsonian Institution in Washington, DC, acquired a group of Aleut mummies from Kagamil Island, one of Alaska's Aleutian Islands. However, his studies of them suggested that he was more interested in their skeletal than their soft tissues (Hrdlička, 1941). It can truly be said that, with a few other isolated exceptions such as Zuki & Iskander's (1943) study of Amentefnekht's mummy, progress of the scientific study of mummies was moderated during this century's second quarter prior to its subsequent advance after 1950.

Reawakening of the third quarter

The extraordinary impetus to development of the technological sciences generated during World War II created a proliferation of new technical applications in the nonmilitary disciplines. Following the first postwar decade, a surge of articles and books gives evidence that mummy investigators were participating in this technological transfer. By 1959 electron microscopical techniques were applied to mummified tissues (Leeson, 1959). Beginning in mid 1950s, Sandison reported his modification of Ruffer's technique for rehydration of desiccated mummified tissues prior to preparation of histological sections (Sandison, 1955a). Attempting to establish relationships between Tutankhamun and his other family members, Connolly & Harrison (1969) employed newer methods of blood antigen serology.

A spate of books and monographs from this period also reflect renewed interest in the study of ancient human remains. Most of these focus on paleopathology, primarily the study of "dry bones". Nevertheless, many include at least certain soft tissue changes. Recognizing the value of understanding postmortem changes in mummified human remains by those who study such tissues, Evans' (1963) treatise *The Chemistry of Death* represents a pioneering effort in soft tissue taphonomy. A published symposium chaired by Jarcho (1966) includes his lament concerning the apathy of paleopathologists for the past several generations. While skeletal pathology is clearly the primary area of interest in this publication, Jarcho (1966) himself notes the potential contributions of trace element analysis, paleoserology, immunodiffusion methodology, X-ray diffraction and serological techniques when applied to mummified tissues. Brothwell *et al.* (1963) produced an edited text (*Science in Archaeology*) that addresses the value of a broad range of both physical and chemical methods of value in studying ancient remains. They included some biological areas such as hair studies and paleoserology methods in a 14 page chapter on the study of mummified human remains written by Sandison. Four years later Brothwell & Sandison (*Diseases in Antiquity*, 1967) published what may still represent the single most comprehensive review of the state of knowledge about diseases in ancient populations. It includes descriptions of parasitic diseases and various types of biological calculi. Janssens' 1970 text *Human Paleopathology* contains only a three page chapter on diseases of the soft tissues.

These major publications, together with a scattering of individual articles, permit us to characterize this interval as a period of paleopathology renaissance. Following several generations of relative inactivity, the general field of paleopathology seemed to require an inventory of existing knowledge in this field before it could resume its progress. Though limited in degree, we also can detect a willingness to apply new laboratory technology to the study of mummified ancient remains. These preliminary proceedings set the stage for the explosion in both numbers and breadth in the range of mummy study methods that began in the 1970s.

Dynamism of the fourth quarter

The symposia, seminars and books about general paleopathology that took place in the previous period

Fig. 1.14. A. Rosalie David and colleagues examining an Egyptian mummy.
Interdisciplinary studies on mummies of the Manchester Museum collection were reported in two seminars in 1979 and 1984. (Courtesy of A. Rosalie David and Manchester Museum, Manchester, England.)

rekindled interest in research on ancient human remains and set the stage for the emerging field of mummy studies. Three events in the early 1970s proved to be epochal for this field of study. The first was the report of Zimmerman's doctoral studies in which he compared the microscopic appearance of synthetically mummified modern tissue specimens with those of Egyptian mummies (Zimmerman, 1972). This became the model for subsequent workers who applied contemporary laboratory techniques within the structure of scientific methodology. The second involved Marvin Allison, Ph.D., of the Medical College of Virginia in Richmond, who initiated a series of summer research visits to Ica, Peru, for the anatomical dissections of Peruvian mummies. Joined soon by the Argentinian physician Enrique Gerszten, M.D., from the same institution, they supplemented their anatomical investigations first with studies of coprolites (dried feces), then radiography and subsequently a host of other, morphological and nonanatomical laboratory methods. By the middle of the decade they had formed a study group, The Paleopathology Club, that still meets concurrently with the annual meetings of the International Academy of Pathology. It also distributes a quarterly newsletter, each issue of which includes a color transparency of a paleopathological lesion. Almost simultaneously Aidan Cockburn, a British epidemiologist working in Detroit, Michigan, and his wife, Eve, organized the dissection of several Egyptian mummies by a multidisciplinary team that

Fig. 1.15. Head of a Guanche mummy, ca. twelfth century.
Chiefs of the indigenous population of Tenerife, Canary Islands, were mummified anthropogenically and placed in caves. (Photo by ACA.)

eventually included more than 75 scientists (Cockburn *et al.*, 1975; Cockburn, 1978). This, too, led to the formation of an organization, The Paleopathology Association, that also meets annually (coordinated with the meeting of the American Association of Physical Anthropologists) and issues a quarterly newsletter. These newsletters communicated results of their mummy studies widely and quickly, and their organizations' conferences provided face-to-face meetings of interested workers. The consequence of these activities was a rapid increase in interest in mummy studies, the number of studies carried out, and the new instrumental applications to those studies. These activities soon expanded to have international and even eventually global scope.

Several spectacular mummies were studied during this period. They include the spontaneously frozen-dried, sacrificed Inca bodies on Andean mountain tops (Reinhard, 1998), the more than 5000-year-old alpine hunter preserved in Tyrolean glacier ice (Spindler, 1994), the cache of hundreds of Chinchorro mummies in Arica, Chile (Allison, 1984b; Arriaza, 1995a), and Acha Man (Aufderheide *et al.*, 1993) who at 9000 years old may be not only the earliest Chinchorro mummy but perhaps one of the oldest mummies discovered anywhere.

During the decade of the 1970s the program of scientific study of the Manchester Museum's mummy collection in England, originated by Margaret Murray in 1910 (see above), was reactivated under the direction of A. Rosalie David (Fig. 1.14). Its initial results were reported by Dr David at an international seminar in 1979, and further studies at a second one in 1984. In addition, an extensive interdisciplinary study (the Cronos Project) of Tenerife's Canary Islands aboriginal population, the Guanche mummies (Fig. 1.15), was carried out in the late 1980s (Rodríguez-Martín, 1996). The results of this project were reported at the First World Congress on Mummy Studies held at Puerto de la Cruz in Tenerife during February, 1992 (Fig. 1.16). Among its goals was the opportunity for the widely scattered mummy investigators to meet each other and develop collaborative research projects. The manuscripts presented there were published three years later by the Archaeological and Ethnographical Museum of Tenerife (1995). The more than 300 attendees from 17 countries were so responsive that the Congress was institutionalized, now meeting regularly every 3 years.

These organizations' activities have continued to recruit an ever-expanding range of investigators from other disciplines. Zimmerman's many studies (1977, 1979, 1980, 1985) have demonstrated the potential contributions that both gross and microscopic anatomical studies can make. The elegant measurements of lead and lead isotope ratios in the tissues of frozen mummified bodies of the arctic Franklin expedition by

Fig. 1.16. Officials of the First World Congress on Mummy Studies, 1992.
From left to right: Rafael González, Director of Archaeological Museum of Tenerife; Arthur C. Aufderheide, President of Scientific Committee; Victoriano Rios, President of the Canarian Parliament; Adan Martín, President of Tenerife Cabildo (government); Manuel Hermoso, Vice-President of the Canarian government; and Miguel Zerolo, President of Museums and Centers of Tenerife's Cabildo. (Photo courtesy of Miguel Zerolo.)

archaeologist O.B. Beattie and colleagues (Kowal *et al.*, 1991) clearly demonstrate how mummy studies sometimes can resolve otherwise unfathomable archaeological problems. Although Flinders Petrie and Grafton Elliot Smith had X-rayed Egyptian mummies shortly after Roentgen's great discovery of this form of radiation, it was not until the popularization of computed tomography (CT scan) in the 1970s with its three-dimensional and other software applications that it became commonly employed in the study of mummified human remains. The ability to gain information without unwrapping a mummy or even removing it from its container was profoundly appealing to museum curators. Some even became so enamored of this procedure that they declared physical dissection was no longer necessary, until it became obvious that the application of this medical instrument to mummies was generating far more information of anthropological interest than biomedical data. While postmortem epithelial cell changes have limited some of electron microscopy's (EM) traditional types of information, when coupled with an electron probe capable of energy dispersive X-ray analysis (EDXA), it is able to identify the elemental nature of crystals. In a study of a diffusely fibrotic destructive lung disease in a mummy, EDXA proved the condition to be due to silicate pneumoconiosis, predictive of dusty occupational (farming) exposure (el-Najjar *et al.*, 1985). Similarly by demonstrating the characteristically deformed red blood cells in mummified tissue, EM enabled diagnosis of sickle cell disease in a prehistoric body (Maat & Baig, 1990).

When Reinhard (1990) found the ova of fish tapeworm in coprolites from the intestines of South America's Chinchorro mummies, he not only confirmed the archaeological suggestion of their maritime subsistence, but also that the Chinchorro people had ingested uncooked fish. Coprolite analysis can also suggest ingested dietary items but skeletal trace element analysis and stable isotope ratio studies in soft tissues can refine prediction of the diet's principal food classes (Aufderheide & Allison, 1995a,b; Tieszen *et al.*, 1995a, b; Aufderheide, 1996). While the ultimate position of immunological studies has not yet been defined, optimism has been created by certain specific achievements such as the immunohistological demonstration of smallpox virus and the trypanosome parasite of Chagas' disease in human mummified tissue (Fornaciari & Marchetti, 1986; Fornaciari *et al.*, 1992a). The identification of cocaine in the hair of South American mummies using techniques of radioimmunoassay and gas chromatography/mass spectrometry permitted Cartmell *et al.* (1991) to supplement archaeological findings by defining the antiquity, geography and demography of prehistoric coca-leaf chewing practices in western South America. Chromatographic techniques also made it possible for Nissenbaum (1992) to demonstrate that bitumen from the Dead Sea instead of the usual resins was employed by some late Egyptian embalmers. Another unique method used in mummy studies involved application of nuclear magnetic resonance spectroscopy to black, radio-opaque material from a mummy's intervertebral disc space. This procedure identified it as resinous embalming material rather than the previously suspected biological deposition of homogentisic acid that would be present in an individual suffering from alkaptonuria (Wallgren *et al.*, 1986). The methods of molecular biology proved the presence of recoverable DNA in human mummies (Pääbo, 1985), and enabled detection of an infectious agent (tubercle bacillus) in a Pre-Columbian mummy by identifying the presence of that bacterium's unique DNA structure (Salo *et al.*, 1994). Other infectious agents identified by this technique in mummies include leprosy bacillus (Rafi *et al.*, 1994); *Trypanosoma cruzi*, the cause of Chagas' disease (Guhl *et al.*, 1999); a leukemia–lymphoma-associated virus HTLV-1 (Li *et al.*, 1999); *Clostridium* spp. in mummy coprolites (Ubaldi *et al.*, 1998); *Bacillus* species from amber-embedded insects (Cano & Borucki, 1995) and others. Mitochondrial DNA patterns in mummified human remains have also helped to define trans-Beringeal human migrations into the New World (Monsalve *et al.*, 1994).

Presently all the limitations for applications of most of these methods to mummified tissues have not yet been defined. Nevertheless, successes to date promise the generation of a new biomedical and biophysical database unimaginable even a generation ago. The relevance and value of such a new body of data will, however, need to be made unmistakably evident. The expense of many of these procedures will place an unprecedented strain on the budget that traditional research funding agencies have made available in the past for investigations of human mummified remains.

This review clearly discloses that the tap root of the scientific discipline of mummy studies is inseparable from the study of both normal and pathological human anatomy. It is equally evident that the pursuit of understanding the human body's structure and function caused the initial, purely morphological methodology to be supplemented by physical, biological, physiological and behavioral techniques. The secondary rootlets of mummy studies became entwined among these methodologies as well. Nourishment from all these sources is not only responsible for the current efflorescence of the scientific study of mummies but has also shaped its present interdisciplinary nature. The future of this discipline lies in the hands of training program directors who recognize how it came to be what it is today, and that its future – indeed its survival – will depend on the nurturing of its interdisciplinary soul.